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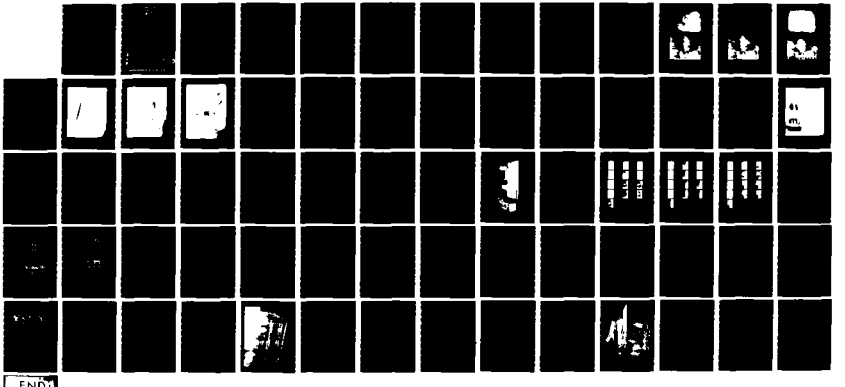

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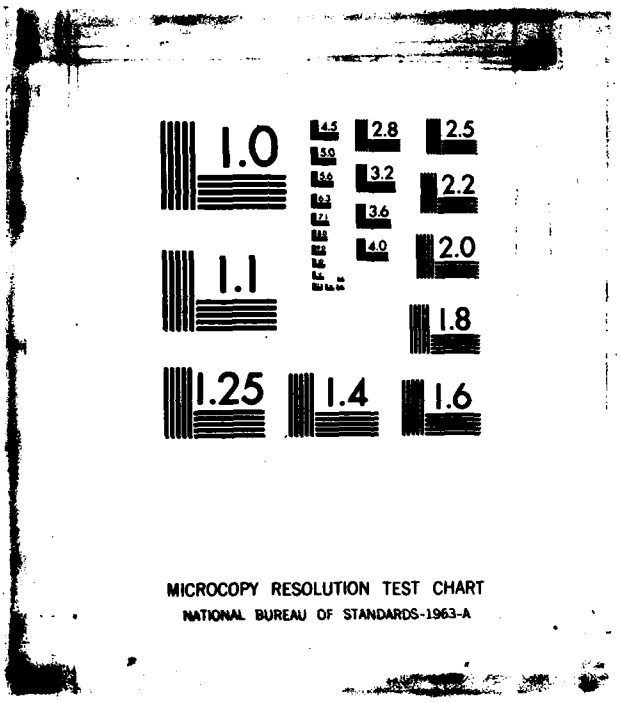
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FLUORESCENCE IMAGE ENHANCEMENT

INSTRUCTION MANUAL

PREPARED FOR:

NAVAL SURFACE WEAPONS CENTER
WHITE OAK LABORATORY
SILVER SPRING, MD 20910

ADVANCED RESEARCH AND APPLICATIONS CORPORATION

FLUORESCENCE IMAGE ENHANCEMENT

Instruction Manual

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This program has resulted in the development of a portable fluorescence image enhancement capability. The processing apparatus provides an advanced development model image enhancement kit suitable for field testing and technical evaluation. This instruction manual contains a detailed description of all aspects of fluorescence image enhancement and an illustrated step-by-step simplified procedure. Only tap water and receptacle voltage need to be provided by the user; all other apparatus and chemicals required to fluorescent dye tone black-and-white negative films are provided.

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20. Abstract (continued)

The toned image can be directly printed using conventional methods to obtain 2 to 4 f/stops of effective speed increase. Alternatively, the fluorescent image can be excited with green light illumination (Wratten No. 55) and rephotographed through a red emission filter (Wratten No. 26 or 29) to obtain 3 to 5 f/stops of effective speed increase.

The lower the fog level of the original image, the more successful the enhancement process will be. Very little enhancement can be obtained for original images having fog levels greater than 0.3 optical density units.

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I INTRODUCTION

Fluorescence image enhancement provides a method for gaining additional information from underexposed imagery or from underexposed (shadow) areas of properly exposed imagery. This intensification process is suitable only for original black-and-white negatives that have been properly fixed and washed.

The degree of enhancement that can be achieved utilizing these methods is extremely dependent upon the fog level of the original image. In general, an original image having a low fog level can be enhanced a great deal, whereas an original image having a high fog level can only be slightly enhanced, if at all. For low fog films, below 0.2 optical density units, excluding the optical density of the film base, it is often possible to obtain 3 to 5 f/stops of effective speed increase over that obtained in the original negative.

The fluorescence enhancement film preparation procedure is about as simple as developing the original negative using conventional 4-step develop-stop-fix-dry methods. The fluorescence enhancement procedure consists of the following eight steps:

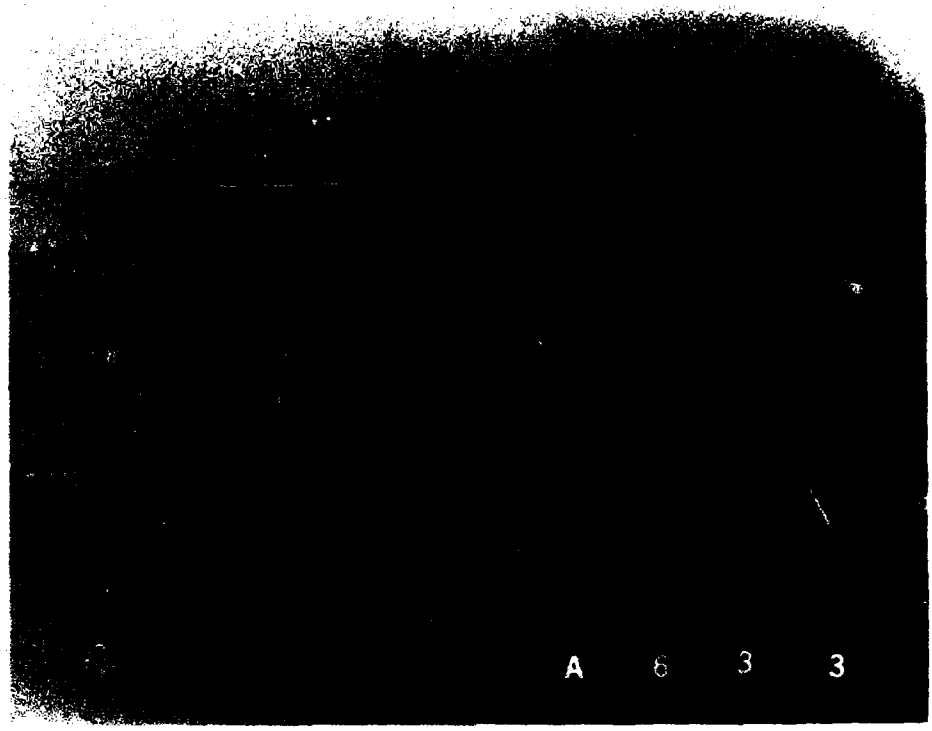
1. Bleach (conversion of metallic silver to silver bromide, 2 min)
2. Water wash (removal of bleach solution, 6 min)
3. Illumination/polymerization (formation of a polymer coating at or on the silver grains, 3 min)
4. Water wash (removal of the polymer solution, 2 min)
5. Dye (absorption of dye by the localized polymer, 5 min)
6. Acetic acid wash (removal of excess dye solution, 10 min)
7. Water wash (removal of acetic acid, 2 min)
8. Dry (5 min)

This 35-minute process results in a pink to red colored image due to the fluorescent dye absorbed by the polymer that is deposited around each silver grain.

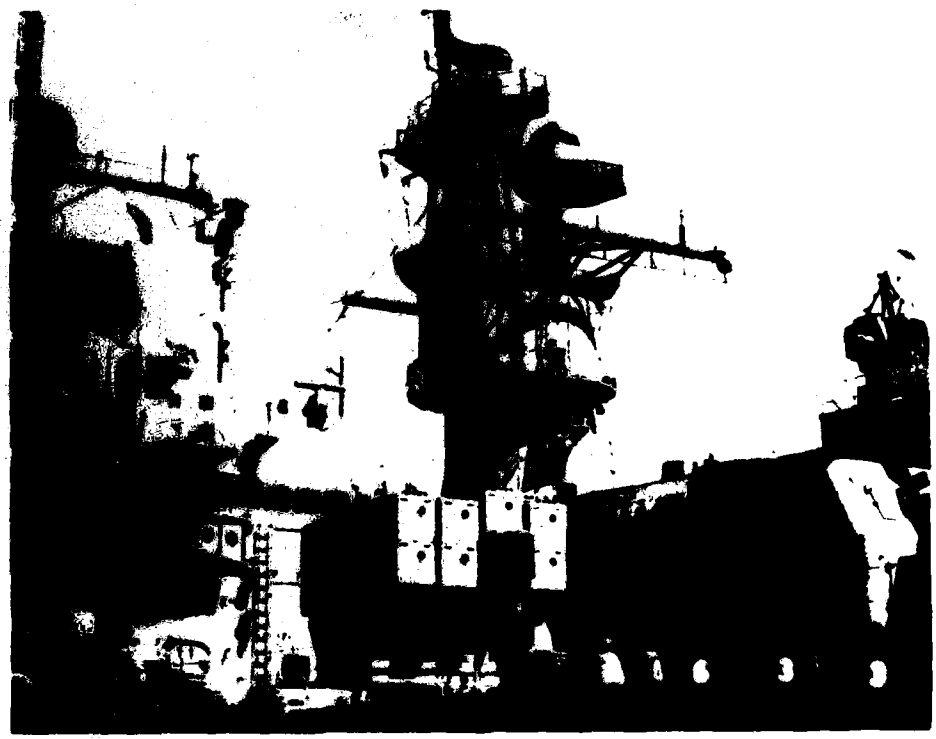
At this point in the procedure, it has often been found that a significant degree of enhancement (2-4 f/stops) of effective speed increase can be achieved by printing the dyed image using conventional contact or enlarging procedures. A high degree of edge-enhancement is often achieved in the prints due to the preferential deposition of the polymer at the edge of an otherwise uniform density image area.

The highest degree of enhancement is achieved by exciting the fluorescent dye with green light and rephotographing the red fluorescent light using a panchromatic black-and-white film such as Eastman Kodak Technical Pan 2415. The rephotography series consisting of 10 to 36 exposures should vary from less than a second to a minute or more for the first experiments. Due to the low contrast of the underexposed image, a high-contrast developer such as Eastman Kodak D-19 is used to develop the fluorescent rephotography film.

Figures 1, 2 and 3 show typical examples of fluorescence image enhancement of underexposed original imagery. While it is never possible to recover all of the information that would have been contained in a "properly" exposed photograph, the fluorescence image enhancement procedure does provide a rapid method of recovering a significant amount of information from an underexposed original image that contained no, or very little, information.

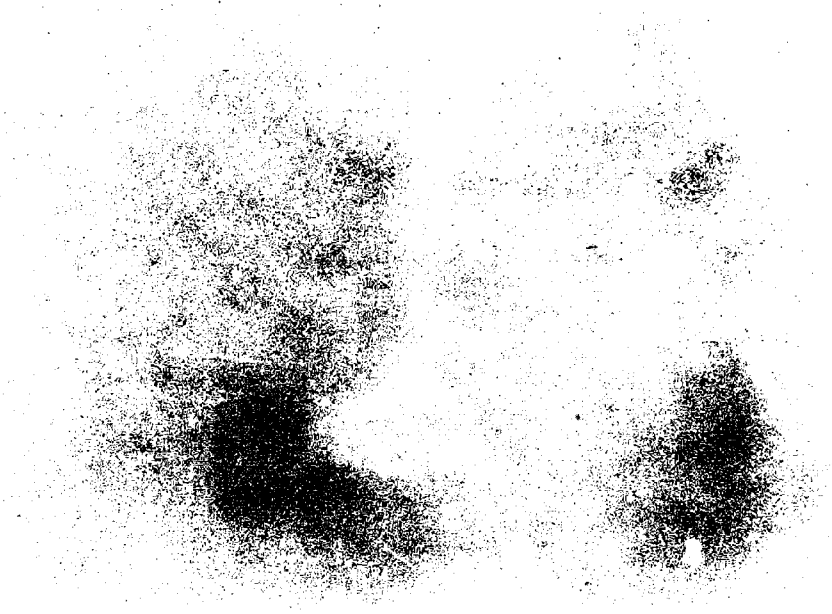


(a) ORIGINAL IMAGE, 3 f/stops UNDEREXPOSED

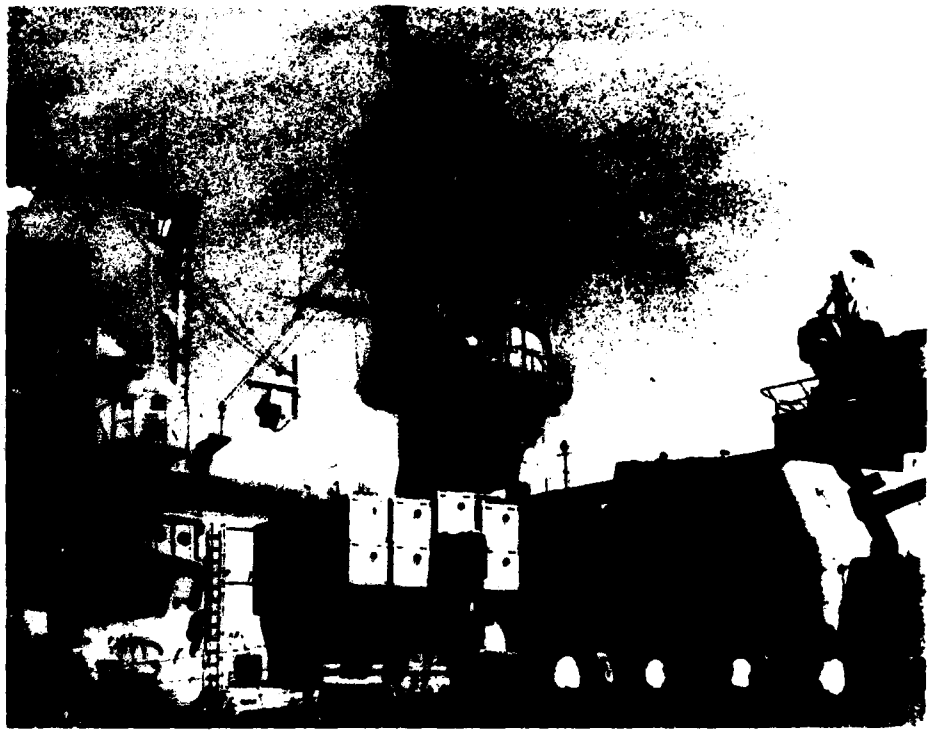


(b) ENHANCED IMAGE USING FLUORESCENCE REPHOTOGRAPHY

FIGURE 1 EXAMPLE OF FLUORESCENCE IMAGE ENHANCEMENT OF ORIGINAL IMAGE A633, EASTMAN KODAK FILM TYPE 2415

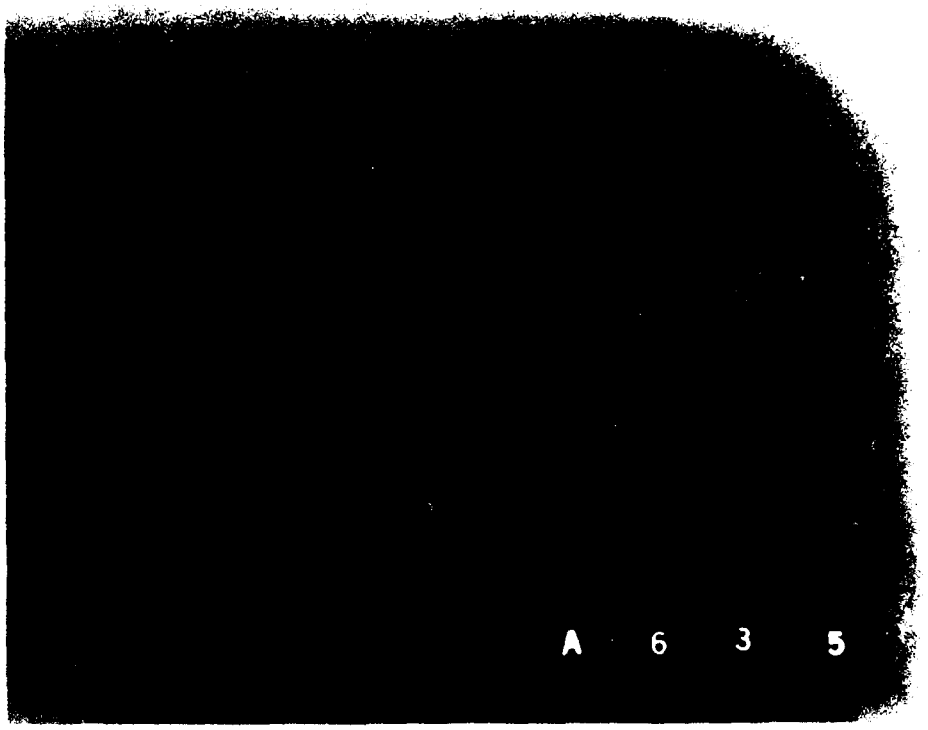


(a) ORIGINAL IMAGE, 4 f/stops UNDEREXPOSED



(b) ENHANCED IMAGE USING FLUORESCENCE REPHOTOGRAPHY

FIGURE 2 EXAMPLE OF FLUORESCENCE IMAGE ENHANCEMENT OF ORIGINAL IMAGE A634, EASTMAN KODAK FILM TYPE 2415



(a) ORIGINAL IMAGE, 5 f/stops UNDEREXPOSED

(b) ENHANCED IMAGE USING FLUORESCENCE REPHOTOGRAPHY

FIGURE 3 EXAMPLE OF FLUORESCENCE IMAGE ENHANCEMENT OF ORIGINAL IMAGE A635, EASTMAN KODAK FILM TYPE 2415

II DYE-TONING KIT

The fluorescence image enhancement toning kit provides an advanced development model (ADM) capability suitable for field testing and technical evaluation. The toning kit can be used with the rephotography and microscopy apparatus developed under Navy Contract N60921-80-C-0169.

Figure 4 shows the toning kit ready for shipment or transport. The kit is contained in a Zero Corporation case constructed of heat treated 2023 aluminum alloy. The outside dimensions of the case are 20, 29, and 10-inches for the width, length and height, respectively. The total weight of the kit is 45 pounds.

A complete inventory of the contents is contained in Tables 1 and 2. The contents list is divided into reusable (Table 1) and expendable (Table 2) materials. The life of the reusable apparatus is estimated to be in excess of 25 sets of the expendable materials. The expendables will be available as recharge kits to renew the capabilities of the Toning Kit to a capacity for treatment of 25 rolls of 36-exposure 35 mm film, or an equivalent area of larger or smaller film formats. The estimated storage life of the chemicals included in the kit is in excess of five years. The interior of the fluorescence image enhancement toning kit is shown in Figure 5. A photograph of the kit inventory is shown in Figure 6.

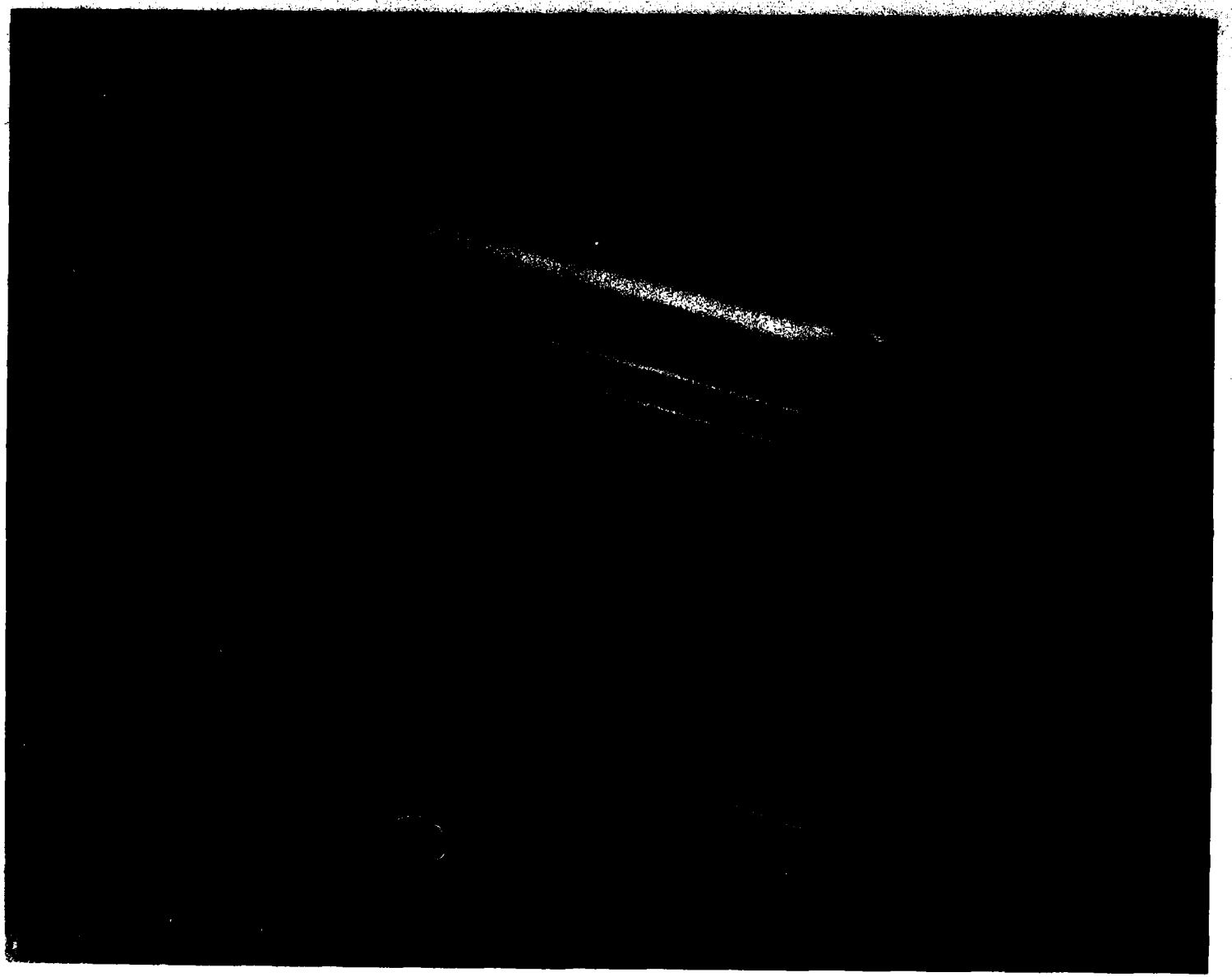


FIGURE 4 ARACOR FLUORESCENCE IMAGE ENHANCEMENT TONING KIT READY FOR SHIPMENT OR TRANSPORT

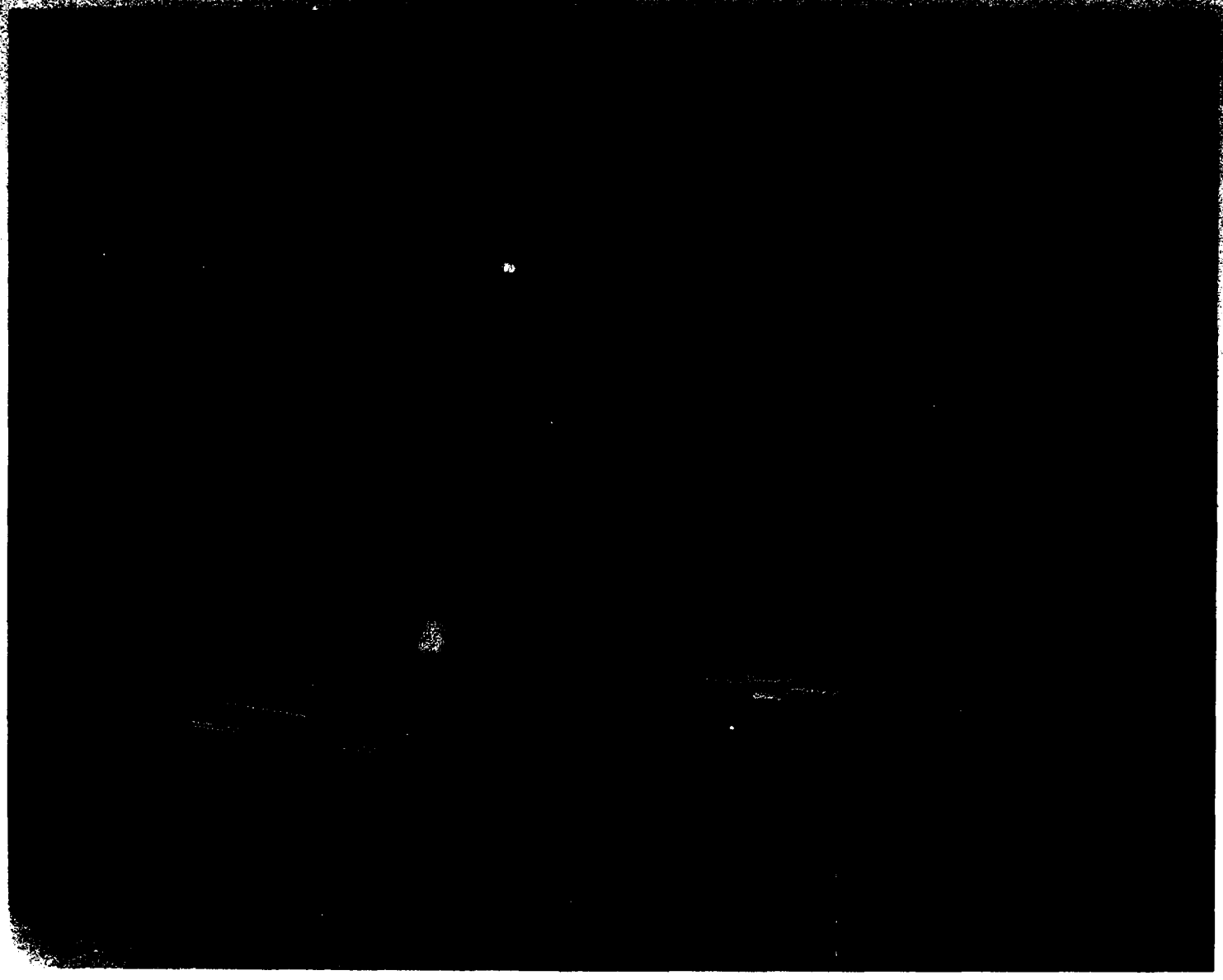


FIGURE 5 INTERIOR VIEW OF THE FLUORESCENCE IMAGE ENHANCEMENT TONING KIT

FIGURE 6 CONTENTS OF THE FLUORESCENCE IMAGE ENHANCEMENT KIT

Table 1

FLUORESCENCE IMAGE ENHANCEMENT TONING KIT INVENTORY

Reusable Apparatus

1 - Instruction Manual / ARACOR
1 - Apparatus Case / Zero Corporation, 129X
1 - Lamp Reflector, 10-inch, Custom Porcelain Base and Cord / VWR Scientific Smith Victor 90 UL, ST401008
1 - Dissecting Scissors, 140 mm / VWR Scientific - 25878-048
1 - Stainless Steel Tweezers / Ted Pella, Inc. - 507
1 - Electronic Timer / VWR Scientific, Gralab 500, 62373-029
1 - Iron Lamp Support with 6.5 Inch Legs / VWR Scientific, 60115-088
1 - Zinc Plated Iron Lamp Support Rod, 0.5 x 24-inch / VWR Scientific, 60115-088
1 - Powder Funnel, Polypropylene, 100 mm / VWR Scientific, 30255-066
1 - Filter Funnel, Polypropylene, 100 mm / VWR Scientific, 30253-129
2 - Custom Plexiglass Trays, 4 x 6-inch / ARACOR
2 - Photographic Developing Trays, 5 x 7-inch / Alpha Photo, Inc., Cesco-Lite P-150
2 - Photographic Developing Trays, 8 x 10-inch / Alpha Photo, Inc., Cesco-Lite P-150
3 - Stirring Rods, 6.5-inch / VWR Scientific, 59063-001
3 - Graduated Cylinders, Nalgene; 50, 250 and 500 cm / VWR Scientific, 24776-064, 24776-100, 24776-122
7 - Beakers, Nalgene; 30, 50, 100, 150, 250, 400, 600 cm^3 / VWR Scientific, 13915-067, 13915-078, 13915-089, 13915-090, 13915-103, 13915-114, 13915-125
2 - Narrow Mouth Bottle, Nalgene, 1.0 liter (for Glacial Acetic Acid / VWR Scientific, 16062-120
1 - Narrow Mouth Bottle, Nalgene, 0.5 liter (for Rhodamine B Dye, VWR Scientific, 16062-109
4 - Narrow Mouth Bottle, Nalgene, 0.5 liter (for Chemical Stock Solutions / VWR Scientific, 16062-109
1 - Clamp Holder 90° / VWR Scientific, 21572-501

Table 2

Expendable Materials

One set is contained in the initial kit. Additional sets are available as recharge kits to each process 25 rolls of 35 mm, 36 exposure negative imagery (or an equivalent area of larger or smaller film formats)

1 - Roll Kapton Tape, 0.5-inch Wide / Saunders S-52
1 - Box Filter Paper, 100-Sheets / VWR Scientific, Whatman No. 54, 28489-100
1 - Plastic Box (for Diacetone Acrylamide) 4 x 6-inch / Stationary Store / EVCO
1 - Plastic Box (for sodium sulfate), 3 x 5-inch / EVCO
1 - Plastic Box (for Sodium Carbonate), 3 x 5-inch / EVCO
1 - Plastic Box (for Bleach), 3 x 5-inch / EVCO
1 - Plastic Box (for Concentrated Acrylic Acid), 3 x 5-inch / EVCO
10 - Narrow Mouth Bottles (for Concentrated Acrylic Acid), Nalgene, 30 cm^3 / VWR Scientific, 16062-029
25 - Bleach Mixture Packets, 13.5 Grams Per Packet / ARACOR
1 - Premixed Dye Solution, 500 cm^3 / ARACOR
10 - Acrylic Acid Concentrate Vials, 30.0 cm^3 Per Vial / ARACOR
60 - Sodium Sulfite Packets, 3.0 Grams Per Packet / ARACOR
10 - Diacetone Acrylamide Packets, 40.0 Grams Per Packet / ARACOR
25 - Sodium Carbonate Packets, 10.0 Grams Per Packet / ARACOR
2 - Photoflood Lamps, 500 Watt, Model ECT / General Electric
2 - Concentrated Acetic Acid Bottles, 1.0 Liter Per Bottle / ARACOR
1 - Roll Vinyl Plastic Electrical Tape / Scotch 33

III DYE-TONING

Stock Solution Preparation

The toning kit provides sufficient chemicals and apparatus for the preparation of all of the stock solutions. In most cases the chemicals have been premeasured and require only dilution with water prior to usage. Liquids can be measured by use of the 50, 250 or 500 cm^3 plastic graduated cylinders. To assure high measuring accuracy, it is necessary to select the smallest graduated container that will contain the entire volume required. Selection of a graduated cylinder larger than the minimum size or using two or more volumes to equal the required total will result in lower measuring accuracy and should, therefore, be avoided.

Stirring rods are provided to mix the diluted chemicals. The stock solutions of bleach, acetic acid, acrylic acid, and diacetone acrylamide can be stored in the four 0.5 liter Nalgene narrow-mouth bottles provided. The following sections give stock solution preparation instructions for each chemical required for fluorescence image enhancement. Table 3 contains a summary of stock solution mixing formulations.

Bleach

A premeasured quantity of granular bleach mixture (13.5 g) is added to 450 cm^3 of water to provide a yellow stock solution containing 2% potassium ferricyanide and 1% potassium bromide. The bleach solution can be reused so the quantity utilized during the bleach step should be poured back into the stock solution through the funnel with filter paper in place after completion of the bleach step. Twenty-five premeasured bleach packets are provided in the kit.

Rhodamine B

The 0.5% rhodamine B dye solution can be used as provided and does not require dilution. It can also be reused so the quantity

TABLE 3. STOCK SOLUTION PREPARATION AND SHELF LIFE

Solution	Kit Form	Preparation of Stock Solution	Stock Solution Concentration	Shelf-Life of Stock Solution	Reuse/ Discard
Bleach	Dry Pre-measured	13.5g (1 packet) + 450 cm^3 water	2.0% K_3FeCN_6 1.0% KBr	3 months discard if precipitate forms	Reusable approx. 5 treatments
Sodium Sulfite	Dry Pre-measured	3.0g (1 packet) + 100 cm^3 water	3.0% Na_2SO_3	Use within 4 hours	Discard after use
Acrylic Acid	Concentrated acid	30 cm^3 (1 vial) + 470 cm^3 water	6.0% AAC	6 months, if stored in brown nalgene container	Discard after use
Diacetone Acrylamide	Dry Pre-measured	40.0g (1 packet) + 200 cm^3 water	20.0% DAAC	6 months, if stored in brown nalgene container	Discard after use
Acetic acid	Concentrated acid	50 cm^3 (measured in graduated cylinder) + 450 cm^3 water	10.0% HAC	2 years	Discard after use
Dye	Stock solution premixed	Not required	0.5% rhodamine-B in 0.5% acetic acid	>5 years	Reusable, filter before restorage

utilized during the dye-toning should be poured back into the stock solution through the funnel with filter paper in place after the dye treatment step. One 500 cm^3 stock solution is provided in the kit.

Acetic Acid

Acetic acid is provided in liquid concentrate form. It must be diluted one part acid to 9 parts water prior to usage as a stock solution. A typical dilution would be 50 cm^3 of acetic acid concentrate added to 450 cm^3 of water to make a 500 cm^3 stock solution. Two 1000 cm^3 (1.0 liter) concentrated acetic acid solutions are provided in the kit.

Acrylic Acid

A premeasured volume of acrylic acid liquid concentrate (30.0 cm^3) is added to 470 cm^3 of water to provide a 6% stock solution. The acrylic acid contains a stabilizing additive that increases the storage-life to 5-years or more. Ten 30.0 cm^3 concentrate solutions are provided in the kit.

Sodium Sulfite

A premeasured weight of granular sodium sulfite (3.0 g) is added to 100 cm^3 of water to provide a clear 3.0% stock solution. This stock solution must be utilized within four hours of preparation or else it must be discarded and a new solution prepared. In the dry solid granular form, sodium sulfite has a storage life greater than 5-years. Sixty 3.0 g sodium sulfite packs are provided in the kit.

Diacetone Acrylamide

A premeasured weight of granular diacetone acrylamide (40.0 g) is added to 200 cm^3 of water to provide a 20% stock solution. Both the dry solid granular form and the stock solution have a storage life greater than 5 years. Ten 40.0 g diacetone acrylamide packs are provided in the kit.

Preparing for Film Treatment

The film is first mounted in one of the five trays provided. The tray selected should be large enough to accommodate all of the photographic images desired, but as small as possible to decrease the solution volumes required to minimize chemical consumption. The tray sizes are 4 x 6, 6 x 7, and 8 x 10-inches, respectively. The number of frames that can be contained in each tray size is dependent upon the size of the film format and is given in Table 4. Any combination of frame sizes can also be treated. The optimum configuration can be determined by laying each frame into the tray emulsion-side up.

The photographic images are attached to the bottom of the tray by the use of the 0.5-inch Kapton Tape. Scissors are included to facilitate the cutting of the tape. Two to four small pieces of tape is adequate to hold the images during the bleach (step 1) and wash (step 2) procedures.

Agitation

Extensive experimentation was conducted during the research program to determine the optimum method of agitation. Rotary, orbital, and intermittent manual agitation were evaluated. Experiments indicated that the best results were obtained using only slight manual agitation during all chemical process steps. This degree of agitation is obtained by lifting one-end of the solution-containing tray about 0.25-inch above the table surface and then immediately lowering it back to the table surface. The repetition rate is non-critical, however, the optimum rate is between two and ten times per minute or once every 30 to 60 seconds, respectively.

Table 4

Photolysis Tray Capacity
(Maximum Number of Frames)

Frame Size	Tray Size		
	4 x 6 inches	5 x 7 inches	8 x 10 inches
35 mm	6	12	36
70 mm	2	4	12
4 x 5 in.	0	1	4

The water-wash time durations given are the minimum times for the agitation rates given. These times can be significantly decreased if the film is washed under running water or if the agitation during washing is more vigorous.

Pretreatment (Optional)

An optional pretreatment of the film with water is recommended if the film is dirty or dusty. Fingerprints enhance very nicely and must be removed using a commercial film cleaner before the bleach step.

Bleach

During the bleach step the image is chemically changed from black metallic silver to white silver bromide by the use of a solution containing 2.0% potassium ferricyanide (K_3FeCN_6) and 1.0% potassium bromide (KBr). The quantity of bleach solution required depends upon the size of the processing tray utilized. Processing trays having sizes of 4 x 6, 5 x 7, and 8 x 10-inches require bleach solution volumes of about 65, 130 and 390 cm^3, respectively.

Independent of tray size selected or chemical step being performed, the chemical volume utilized is that which completely covers the film mounted in the processing container with a margin of 1/16 to 1/4-inch.

The bleach agitation time is 2-minutes or until the entire black silver image is converted to a white silver bromide image. All process times are determined by use of an electronic timer set to the predetermined time for each process step. An audible tone sounds at the completion of the time period. Instruction for the use of the electronic timer is provided in Appendix A.

At the conclusion of the bleach step, the solution can be poured back into the stock solution for reuse.

If the original black metallic silver image is not completely converted to white silver bromide after 3 minutes, the bleach stock solution is spent and the bleach step must be repeated with a new stock solution.

The most critical wash step of the entire procedure is that following the bleach step. Three 2-minute washes are recommended, however it is imperative that no yellow bleach solution remain in the processing tray. Care must be taken to wash out any bleach solution that becomes trapped between the back of the film and the tray. The film should be removed from the bleaching tray by lifting the tape with tweezers and then held under running water to assure removal of all of the bleach solution. Any residual bleach solution will spontaneously cause non-localized growth of polymer and poor results.

Photolysis

During the photolysis step, the silver bromide image is converted back to metallic silver with the release of a bromine radical. The interaction of the bromine radical with the surrounding monomer solution results in the localized deposition of polymer at the silver grain site.

It is recommended that one of the trays be selected for the photolysis step and never used for bleaching. The film is remounted in this tray with fresh tape prior to the photolysis.

The photolysis lamp assembly consists of a stand, long vertical rod, short horizontal rod, right-angle rod clamp, light reflector and a 500 watt photoflood lamp. Assembly is straightforward and is facilitated by examining the completed photolysis apparatus shown in Figure 7. The lamp is connected to the electronic timer. The lamp will turn-on when the timer is started for the photolysis step and will turn-off at the completion of the

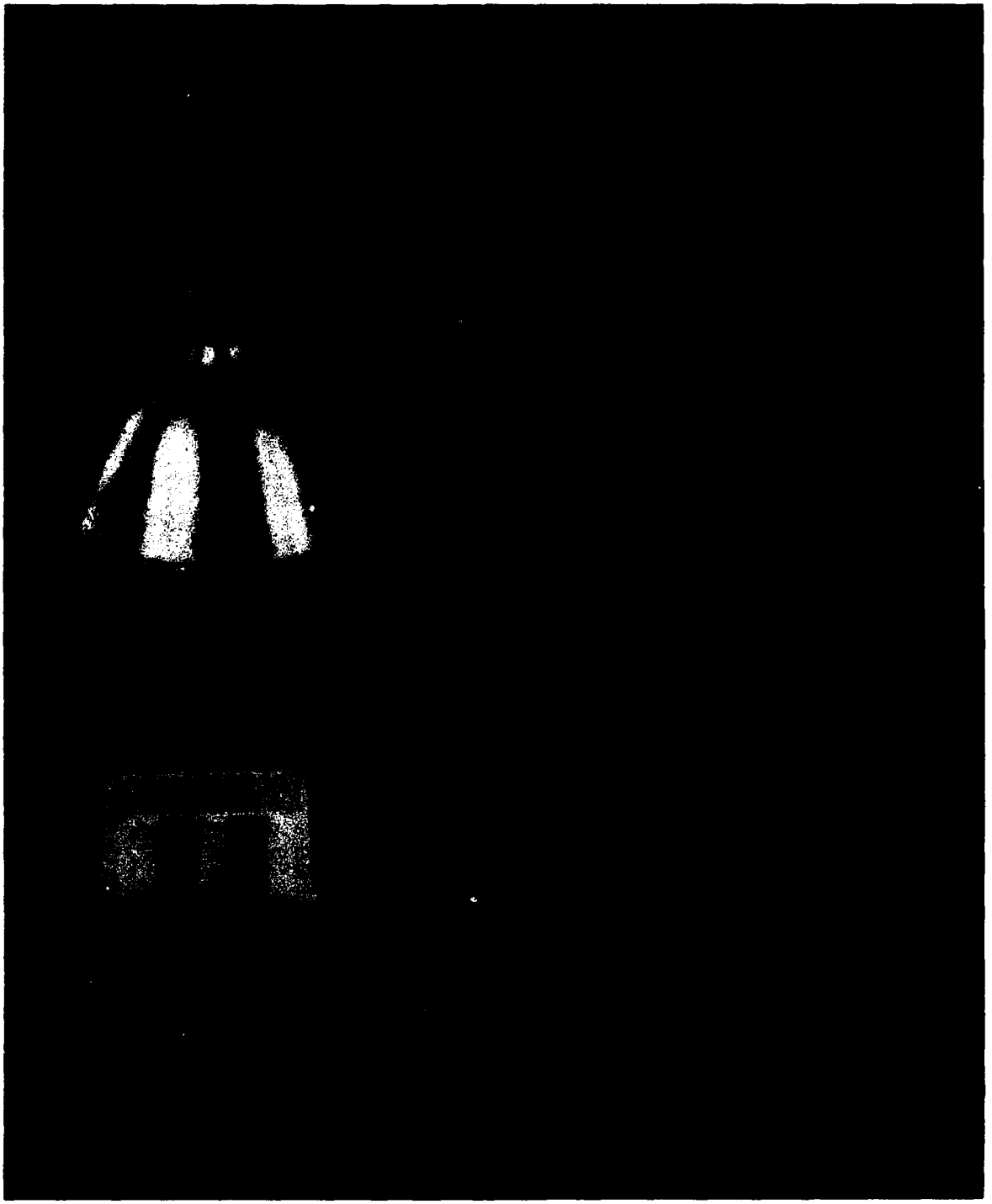


FIGURE 7 APPARATUS CONFIGURATION FOR PHOTOLYSIS POLYMERIZATION STEP

preset time. The height of the lamp should be adjusted to provide 10,000 ft-candles of illumination to the film in the tray (approximately 12 inches). The illumination level can be checked by the use of an incident light meter that has been set to make readings at an ASA of 100. With the meter held in the center of illumination the meter should read 1/250 second at f/11.

The chemicals and their respective quantities to prepare the monomer solution are summarized in Table 5.

Table 5

Monomer Solution Preparation
(Quantities From Stock Solutions)

Addition Sequence	Process Tray Size		
	4 x 6 inches	5 x 7 inches	8 x 10 inches
Sodium Sulfite (3.0%)*	25 cm^3	50 cm^3	150 cm^3
Acrylic Acid (6%)	25 cm^3	50 cm^3	150 cm^3
Diacetone Acrylamine (20%)**	15 cm^3	30 cm^3	90 cm^3
Total volume of chemicals	65 cm^3	130 cm^3	390 cm^3

*This chemical must be freshly made within four hours prior to monomer solution preparation.

**This chemical must be added just prior to activating the photolysis timer.

Choose a beaker that is at least twice as large as the total volume of chemical required for each photolysis. Measure the acrylic acid stock solution in a graduated cylinder and pour into the beaker. Without rinsing, measure the sodium sulfite stock solution into the same graduated cylinder and add to the beaker. The graduated cylinder should then be rinsed with water a few times to remove the acrylic acid and sodium sulfite. The diacetone acrylamide stock solution is then measured into the graduated cylinder but IS NOT ADDED to the beaker containing the other two components at this time.

The photolysis lamp is assembled and positioned to provide 10,000 ft-candles of illumination (approximately 12-inches above the film). Insert the lamp's plug into the timer receptacle marked "enlarger" and set the timer for 3-minutes. A photograph of the photolysis polymerization apparatus is shown in Figure 7.

The following four steps are to be accomplished sequentially within a period of 10 to 15-seconds.

- Pour the diacetone acrylamide solution from the graduated cylinder to the beaker containing the sodium sulfite and acrylic acid solutions and mix with a stirring rod or by gentle swirling.

- Pour the entire monomer solution into the tray containing the bleached and washed film that is taped emulsion-side-up.

- Agitate the tray for a few seconds.

- Activate the timer to turn on the photolysis lamp for three minutes.

During the photolysis, a minimal rocking agitation is maintained (two-to-five-times-a-minute). At the conclusion of the two-minute photolysis, the lamp will automatically turn-off. It is important to immediately discard the monomer/polymer solution and wash the processed film to terminate the polymerization. The taped film may be detached and held under rapidly flowing water to complete the water wash or washed 2 times for 1 minute duration each time.

It is best to wash both the beaker used for mixing the monomer solution and the polymerization tray immediately after washing the film to prevent the insoluble polymer from forming a difficult-to-remove scum or cake. Methanol, not contained in the kit, will readily dissolve any residue of white polymer.

Dye Attachment

During the dye attachment step, the localized polymeric image is treated with the dilute stock solution of rhodamine B dye. The fluorescent dye is absorbed by the localized polymer image.

It is best to choose one of the small trays for exclusive use as "the dyeing tray." It wil eventually become stained red and may cause cross-contamination with other reusable solutions if this tray is used for other steps of the procedure. The treated films do not need to be taped to the bottom of the tray during dyeing. It is easy to assure that a few single frames do not stick together or float, but when many frames or a multi-frame strip is to be dyed, taping can assure uniform dyeing. Individual 35 mm frames require only one piece of tape, whereas, a strip of 4 to 6 frames requires two pieces of tape per strip.

Pour sufficient dye stock solution to cover the negatives and set the timer for five minutes. Agitation is not necessary during the dyeing step. While waiting, insert the funnel with filter

paper into the dye stock solution bottle. At the completion of the 5-minute dyeing process, pour the dye into the stock solution bottle through the filter/funnel combination. Use a 20 to 30-second water rinse to remove the excess dye from the film. The processing tray and funnel should also be rinsed to minimize staining by the dye.

Acetic Acid Wash

Although the water rinse removes most of the excess dye, some dye that is not localized on the image remains in the film's emulsion. If not completely removed, this dye will decrease the degree of enhancement otherwise achievable by lowering the image contrast. Two 5-minute soakings in 10% acetic acid stock solution will remove the excess dye while not removing the dye that has been absorbed by the polymer.

With the images still attached to the tray used for dyeing, pour in sufficient acetic acid stock solution to cover the processed films. Agitate gently once-a-minute and make certain that the solution is able to wash the back as well as the emulsion side of the film. At the end of five minutes, discard the solution, add fresh acetic acid stock solution, and agitate for another five minutes.

The two five-minute washes should be sufficient for images that have a low fog level. However, high fog films result in excess dye deposition in non-image areas, easily noticed around sprocket holes. This excess dye should be removed by extending the wash to include a third or, if required, a fourth wash in the acetic acid stock solution.

The experienced user can quickly determine the optimum wash time by visual inspection. The inexperienced user can obtain the same optimum results by completing acetic acid wash/re-photography

cycles. If too much dye is removed by washing, it is always possible to redye the image and rewash for a shorter time. The film is then water-washed one-time for two minutes duration to remove residual acetic acid. This water wash completes the dye-toning step. The dye-toned image is then air dried.

Dye Removal (Optional)

At the completion of the enhancement procedure, the rhodamine B dye may be removed by a 10-minute treatment in 1% sodium carbonate solution followed by three 2-minute water washes. Redevelopment of the silver bromide grains that were not converted to silver during the photolysis step is accomplished by treatment for 5-minutes in any black and white developer followed by two water washes for two minutes duration. No fix step is required. The image can then be returned to archival storage in its original form, except for the invisible localized polymer surrounding each grain.

If in the future it is desired to obtain additional enhancements of processed images it is necessary to repeat the process starting with the dye attachment step.

Dye Toning Process Summary

The entire polymeric dye attachment (toning) process is summarized in Table 6. The kit user will find that this information provides a useful guide and reminder of important aspects of each of the process steps.

TABLE 6. SUMMARY OF THE DYE TONING PROCESS

Step Number	Function	Duration	Agitation Per Minute	Reuse/ Discard	Comments
-	-	-	-	-	Mount film emulsion-side-up in tray with tape.
0	Optional rinse or clean	3 times, 2 min	Continuous	Discard	Removes dust, dirt and fingerprints.
1	Bleach	1 time, 2 min	5/min	Rinse	Converts the metallic silver image to silver bromide. If the black image does not turn white after 2 min, mix fresh stock solution and repeat.
2	Water Wash	3 times, 2 min	Continuous	Discard	Loosen film from tray to ensure that no bleach is trapped. A complete removal of the yellow bleach is extremely important.
-	Monomer Preparation	-	-	-	Set up light and plug into timer, remount film in tray. See Table 5 for monomer solution preparation quantities from stock solutions. Add sodium sulfite to the acrylic acid in a beaker, wash graduated cylinder and measure diacetone acrylamide but do not add to beaker until photolysis is to be initiated. Then pour diacetone acrylamide into beaker with the sodium sulfite and acrylic acid, swirl, quickly pour into processing tray with mounted film, activate timer.

TABLE 6. SUMMARY OF THE DYE TONING PROCESS (Continued)

Step Number	Function	Duration	Agitation	Reuse/ Discard	Comments
3	Polymer Formation	1 time, 3 min	4/min	Discard	Forms localized polymer at or on the silver grains.
4	Water Wash	2 times, 1 min	Continuous	Discard	Wash film and apparatus to prevent polymer formation.
5	Dye	1 time, 5 min	Not required	Reuse	Pour back into stock solution through filter paper. Rinse film for 10-30 seconds to remove dye.
6	Acetic Acid Wash	2 times, 5 min	Continuous	Discard	Removes excess dye.
7	Water Wash	1 time, 2 min	Continuous	Discard	Removes acetic acid.
8	Air Dry	As required	-	-	Avoid dust.

IV IMAGE ENHANCEMENT

Once the image to be enhanced has been treated and toned with dye, it has often been found that a degree of enhancement (2-4 f/stops) of effective speed increase can be achieved by printing the dyed image (polymeric dye attachment) using conventional contact or enlarging procedures. A high degree of edge-enhancement is often achieved in the prints due to the preferential deposition of the polymer and dye at the edge of an otherwise uniform density image area. A high contrast printing paper usually results in superior results.

The highest degree of enhancement is achieved by exciting the fluorescent dye with green light (Wratten No. 55) and rephotographing the red fluorescent light through a red emission filter (Wratten No. 26 or 29) using a panchromatic black-and-white film such as Eastman Kodak Technical Pan 2415.

A suitable rephotography apparatus is shown in Figure 8. The system consists of a Nikon F2AS Photomic 35 mm Camera with a Micro-Nikkor 55 mm f/2.8 lens. The Nikon Auto Extension Ring PK-13 allows 1:1 rephotography. Focusing through the Nikon DW-2, 6X magnifier allows 1:1 rephotographs having greater than 80 lp/mm resolution. This apparatus is part of a fluorescence image enhancement optical kit that was developed under Navy Contract No. N60921-80-C-0169. A full description of the optical kit is included in Section V.

Intensification by fluorescence rephotography is conducted by varying the exposure to control the degree of intensification. Severely underexposed original images require longer fluorescence photography exposures than moderately underexposed original images. The novice user can fully bracket the exposure range by beginning an exposure sequence with 1/4, 1/2, and 1 second exposures and then completing the sequence with timed exposures

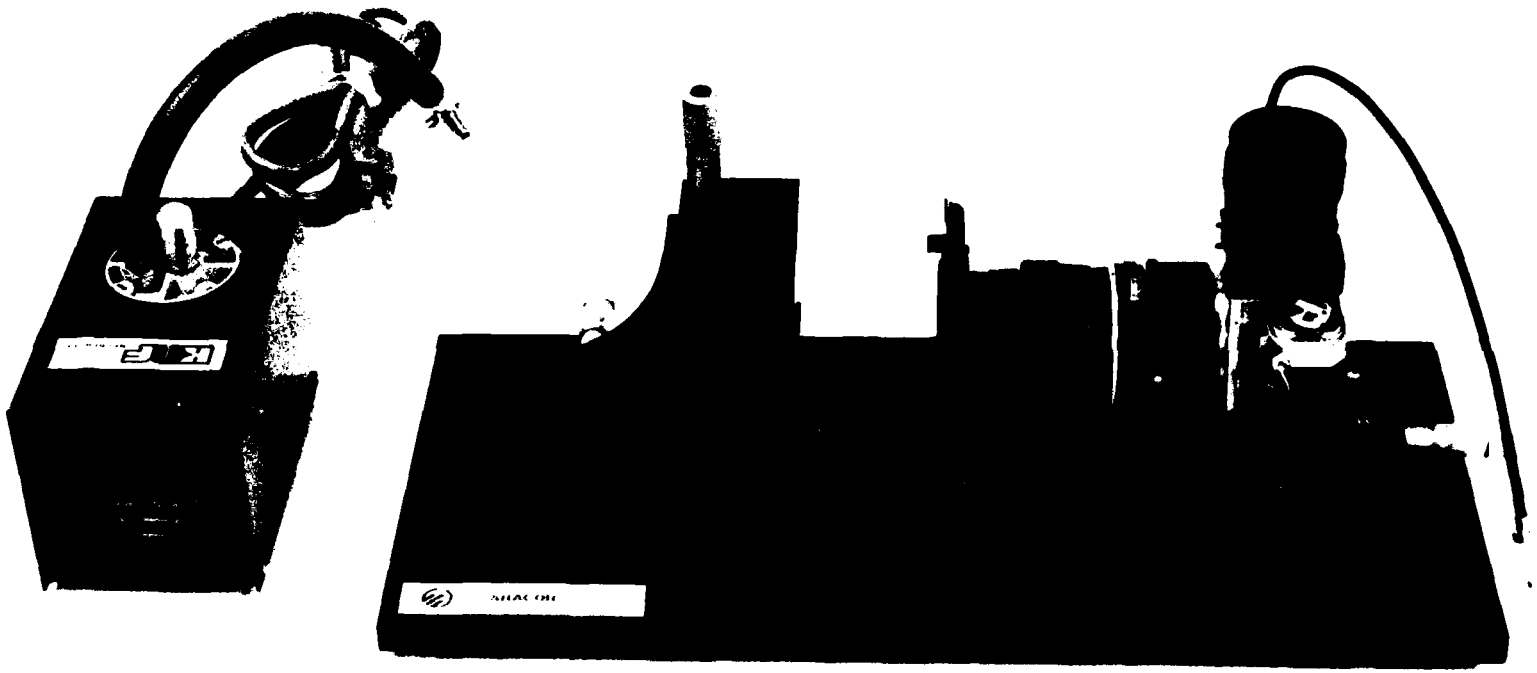


FIGURE 8 FLUORESCENT IMAGE REPHOTOGRAPHY APPARATUS

using the B setting for exposures of 2, 4, 8, 16, 32, 64 (1m 4s), 128 (2m 8s), 256 (4m 16s), and 512 seconds (8m 32s). These 12 exposures will bracket the optimum exposure and permit enhancement of 3 frames of imagery per 36 exposure roll of 2415. The experienced user can greatly reduce the number of exposures required to bracket the optimum exposure. Development of the enhanced images should be conducted with a high contrast developer such as D-19 (4.0 min at 68°F) followed by 0.5 minute in one percent acetic acid and 3 minutes in rapid fix. After inspecting the processed rephotography film, it may be desirable to obtain additional exposures at intermediate exposure times to provide a narrower range of enhancement exposures in the optimum range or to obtain additional copies of optimally exposed images.

A comparison of photographic image enhancement methods utilizing polymeric dye attachment is shown in Figures 9, 10, and 11. The sequence at the top of the page shows the original image varying from the correct exposure to 5 f/stops underexposed. The sequence in the middle of the page shows the degree of image enhancement that can be achieved by fluorescence rephotography. The sequence at the bottom of each figure demonstrates the degree of enhancement that can be achieved by direct printing of the dye-toned image without taking advantage of the fluorescence rephotography step. While a significant enhancement may be obtained by direct printing, it has been found that one-to-two additional f/stops of effective film speed can usually be obtained by conducting rephotography of the fluorescent image.

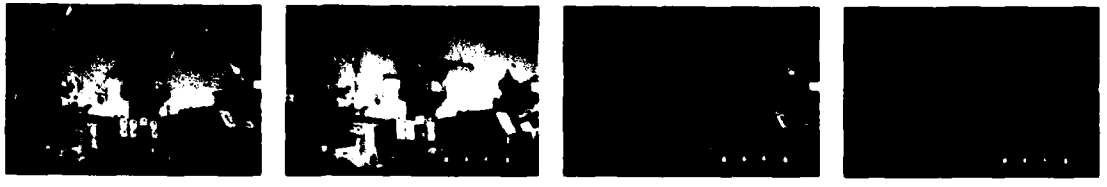
ORIGINAL IMAGE

Frame A620 Correct Exposure | Frame A622 -2 f/stops | Frame A623 -3 f/stops | Frame A624 -4 f/stops | Frame A625 -5 f/stops

ENHANCEMENT OF THE ORIGINAL IMAGE BY FLUORESCENCE REPHOTOGRAPHY

Frame A622 | Frame A623 | Frame A624 | Frame A625

ENHANCEMENT OF THE ORIGINAL IMAGE BY PRINTING AFTER FLUORESCENCE DYE TONING



Frame A622 | Frame A623 | Frame A624 | Frame A625

FIGURE 9 COMPARISON OF PHOTOGRAPHIC IMAGE ENHANCEMENT METHODS UTILIZING POLYMERIC DYE ATTACHMENT

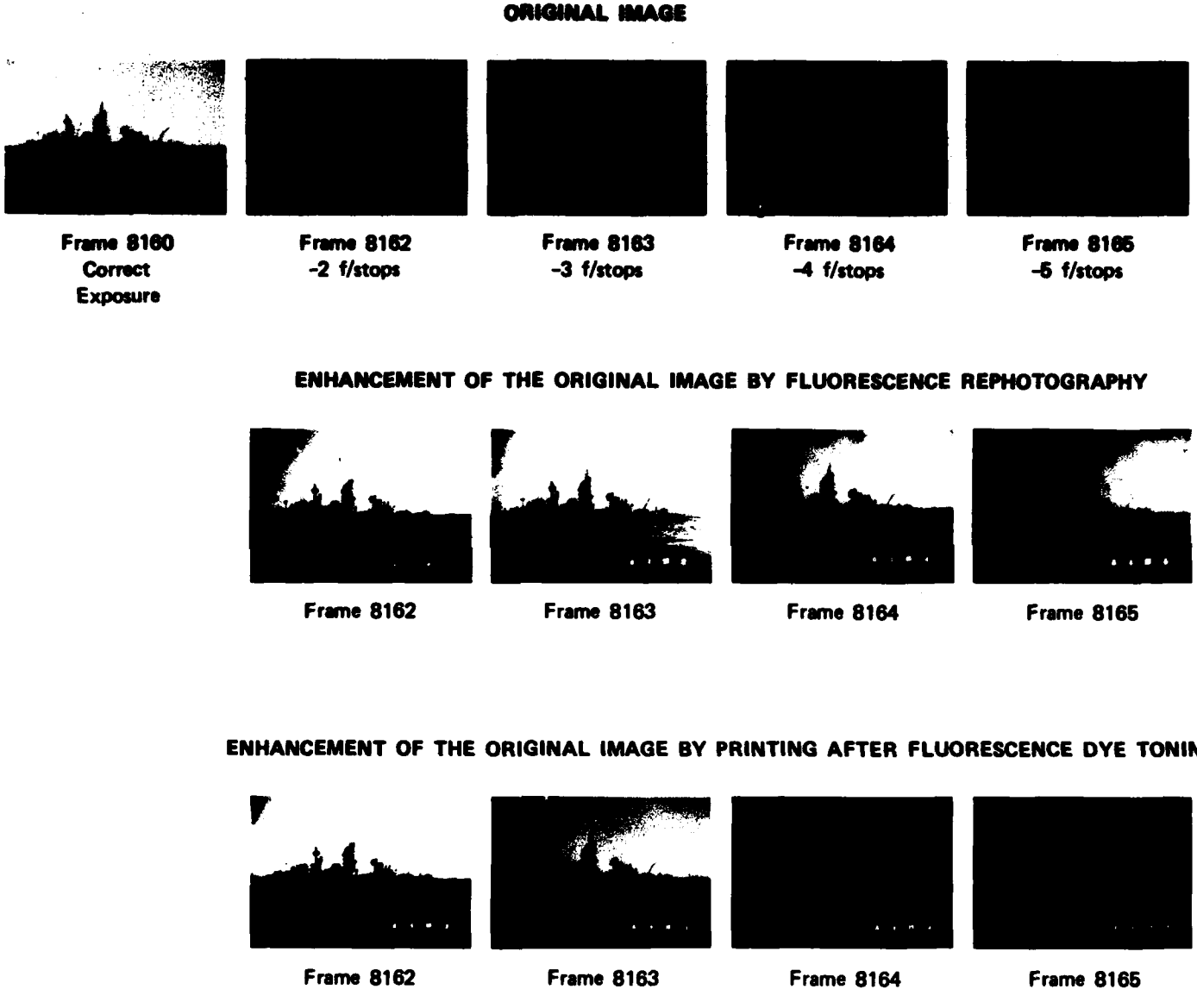


FIGURE 10 COMPARISON OF PHOTOGRAPHIC IMAGE ENHANCEMENT METHODS UTILIZING POLYMERIC DYE ATTACHMENT

ORIGINAL IMAGE

Frame 790 Correct Exposure | Frame 792 -2 f/stops | Frame 793 -3 f/stops | Frame 794 -4 f/stops | Frame 795 -5 f/stops

ENHANCEMENT OF THE ORIGINAL IMAGE BY FLUORESCENCE REPHOTOGRAPHY

Frame 792 | Frame 793 | Frame 794 | Frame 795

ENHANCEMENT OF THE ORIGINAL IMAGE BY PRINTING AFTER FLUORESCENCE DYE TONING

Frame 792 | Frame 793 | Frame 794 | Frame 795

FIGURE 11 COMPARISON OF PHOTOGRAPHIC IMAGE ENHANCEMENT METHODS UTILIZING POLYMERIC DYE ATTACHMENT

V OPTICAL KIT

The fluorescence image enhancement optical kit provides a prototype capability for the rephotography and microscopy enhancement of fluorescent photographic images. The optical kit, together with the apparatus, procedures and chemical deliverables of Navy Contract No. N60921-80-C-0166, provide the Navy with a complete advanced development model (ADM) fluorescent image enhancement capability.

All of the apparatus included in the fluorescence image enhancement optical kit is shown in Figures 12 and 13. A complete inventory is contained in Table 7.

The apparatus contained in the optical kit is delicate and requires extreme care during unpacking, usage, and repacking. The equipment is packed in the metal case by the use of custom cut foam panels. The foam panels are numbered from one to nine (the respective numbers written in black and located at the four corners of each of the foam pieces. The panels must be sequentially removed (one to nine) and repacked (nine to one) to obtain the required protection for each individual kit component. Care should be taken not to rip the fragile foam. The unpacking sequence is given in Table 8. The packing sequence is the reverse of the unpacking sequence.

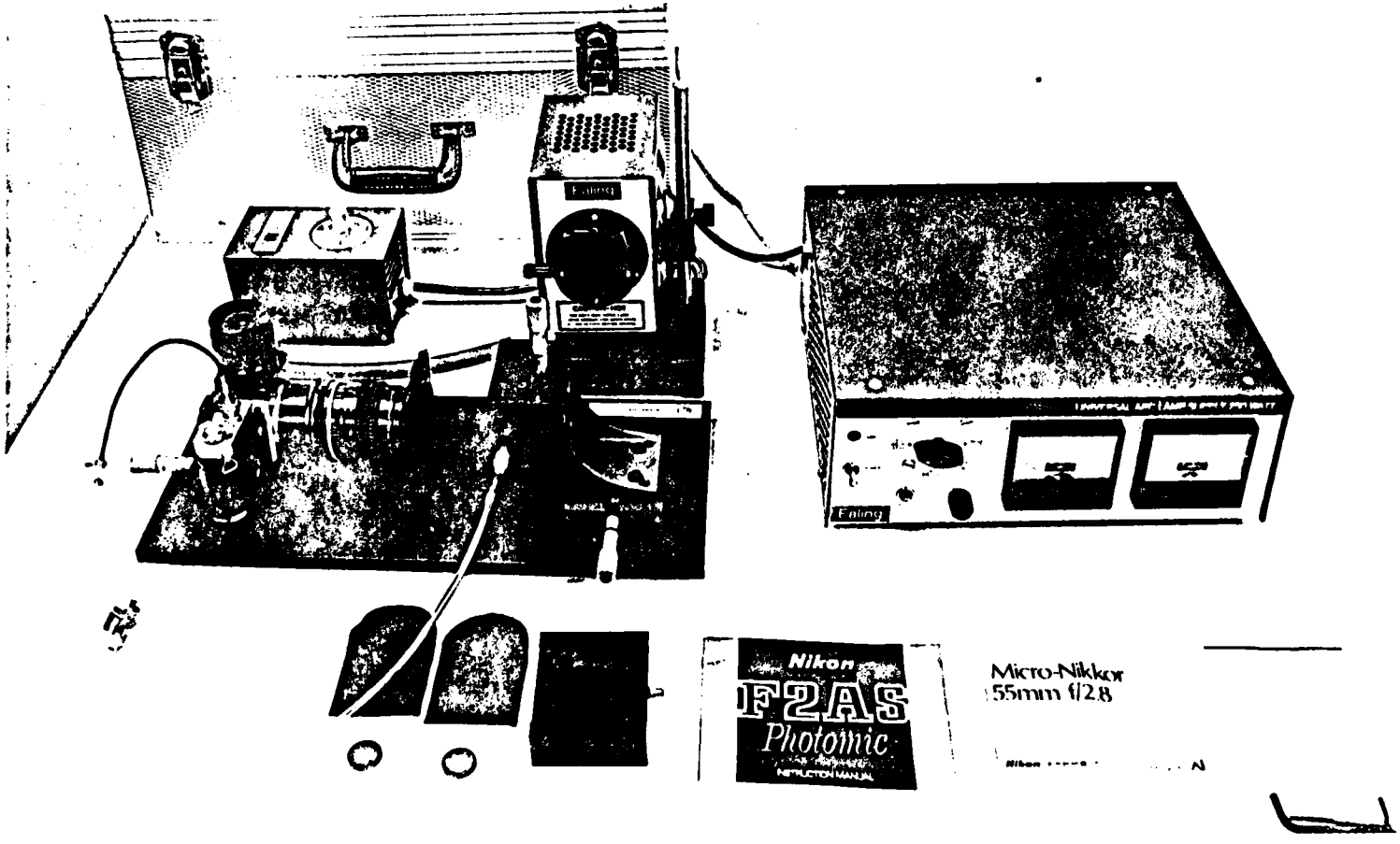


FIGURE 12. ARACOR FLUORESCENCE IMAGE ENHANCEMENT OPTICAL KIT. OPTICAL KIT INVENTORY

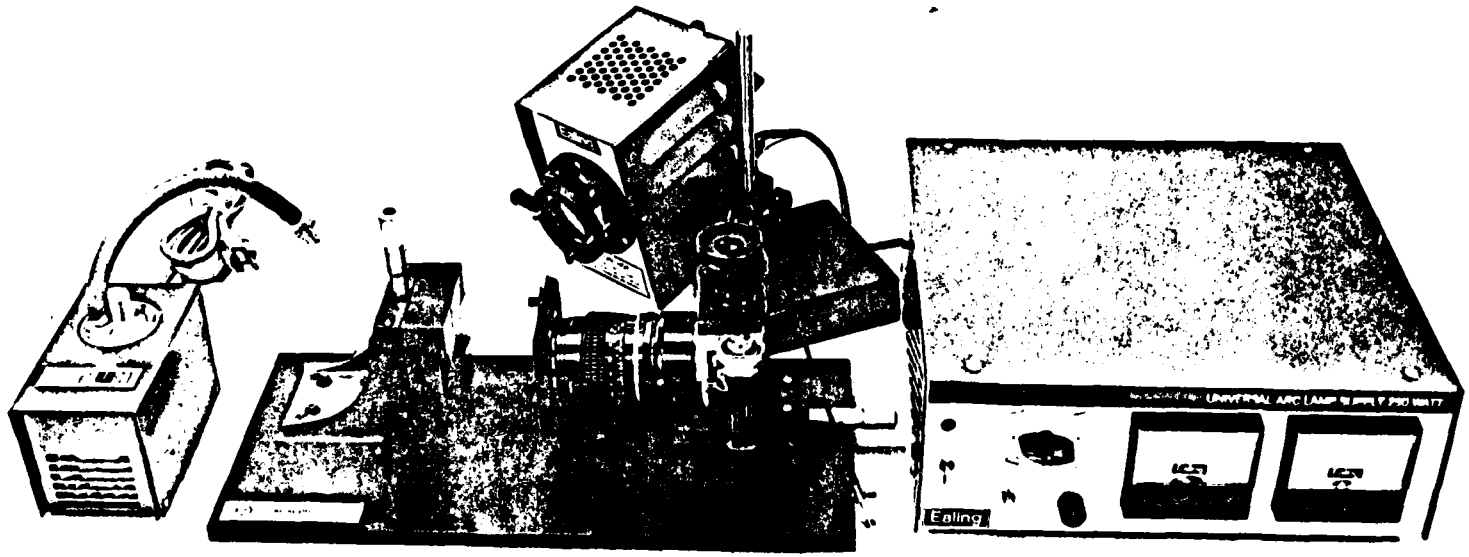


FIGURE 13. ARACOR FLUORESCENCE IMAGE ENHANCEMENT OPTICAL KIT. FLUORESCENCE PHOTOGRAPHY

Table 7

FLUORESCENCE IMAGE ENHANCEMENT OPTICAL KIT INVENTORY

1 - Nikon F2AS Photomic 35 mm Camera/Nikon
1 - Micro-Nikkor 55 mm f/2.8 Lens/Nikon
1 - Nikon L37, UV filter, 52 mm/Nikon
1 - Nikon Auto Extension Ring PK-13/Nikon
1 - Stabilarc-100 Lamphouse/Ealing 27-1411
1 - Universal Arc Lamp Supply 250 W/Ealing 27-1015
1 - Cable (Stabilarc-100 Lamphouse to Universal Arc Lamp Supply)/Ealing 27-1152
2 - Mercury Arc Lamp, 100W/Ealing 28-8480 (one installed, one spare)
1 - Lamp Stand/Ealing 27-0084
1 - Iris, 49 mm (2-33 mm)/Ealing 2203917
1 - Technical Filter Holder,Kenko 52S
1 - Focusing Magnifier/Nikon DW-2, 6X/Nikon
1 - Custom Translation Camera Mount ARACOR
1 - Vacuum Pump/Neuberger
1 - Medium Band Pass Filter/Turner 110-832
1 - Sharp Cut-off Filter/Turner 25/110-824
2 - Sharp Cut-off Filter Modified to 24 $\pm$ 1 mm Diameter/Melles Griot RG 610
1 - Fluorescent High Resolution Target/ARACOR
1 - Cable Release Adapter/Kalt Corporation 3001
1 - Cable Release/Kalt Corporation RS-12
1 - Nikon F2AS Photomic-Instruction Manual/Nikon
1 - Micro-Nikkor 50 mm f/2.8-Instruction Manual/Nikon
1 - Rephotography and Microscopy Apparatus for Fluorescence Image Enhancement-Instruction Manual/ARACOR
1 - Apparatus Case/Fiberbilt
1 - Vacuum Hose Assembly with LUER-LOK Fittings/ Becton-Dickinson
1 - 35 mm Vacuum Platten/ARACOR
1 - 70 mm Vacuum Platten/ARACOR
1 - Set Allen Wrenches/ARACOR

Table 8

OPTICAL KIT UNPACKING SEQUENCE

Step	Foam To Be Removed	Apparatus To Be Removed
1		Instruction Manuals
2	Number 1	
3	Number 2	
4		Vacuum Hose, Optical Filters, Shutter Cable, Allen Wrenches, Vacuum Platten, Extra Mercury Lamp
5	Number 3	
6	Number 4	
7	Number 5	
8		Lamp Stand
9	Number 6	
10*	Number 7	Vacuum Pump, Lamp, Rephotography Apparatus

* Foam panels Number 8 and 9 remain in the metal case at all times.

VI FLUORESCENT IMAGE PHOTOGRAPHY APPARATUS

General

Detailed descriptions of the universal arc lamp supply, and the Stabilarc 100 lamphouse are included in Appendices A and B, respectively. Instruction manuals for the Nikon F2AS camera and 55 mm f/2.8 lens are included in the optical kit separately.

Power Requirements

The vacuum pump and mercury lamp power supply require 120 VAC, 60 Hz, 1 Ampere and 6.5 Ampere, respectively. Both devices utilize standard 3-pin grounded plugs.

Installation

The Nikon camera with lens and filter is mounted to the precision focusing vacuum platten by means of a 1/4 inch-20 allen screw accessible from beneath the base. With the PK-13 auto extension ring in place between camera and Micro-Nikkor 55 mm f/2.8 lens and the focus fully extended, the image obtained during rephotography will be the same size as the original image (magnification of unity). An L37 52 mm UV filter screw mounts into the Micro-Nikkor lens and the 52 mm Kenko technical filter holder screws into the UV filter. The square Turner No. 25 sharp cut-off filter (>595 nm) is held by the Kenko holder.

The vacuum pump is attached to the vacuum platten film holder by a LUER-LOK fitting assembly consisting of a rubber vacuum hose, a three-way stopcock, and a plastic vacuum hose.

The mercury arc lamphouse and stand assembly is attached to the universal arc lamp lamp supply by means of a special cable. The two multi-pin plugs allow installation in only one way. A ground wire connection is required on the terminal provided on the lamp housing. The lamp selection switch on the front panel must be in the "100 HG 5-6.9A" position. The green 50 mm square medium band pass filter is positioned in the lamp housing filter holder. The aspheric condenser has been removed from the lamp housing to obtain more uniform illumination.

Vacuum Platten

Vacuum plattens to accommodate 35 and 70 mm film sizes are provided in the optical kit. The appropriate size platten for the film size to be enhanced is chosen and mounted on the Y-Z film transport stage. The fluorescent film is held flat during rephotography by use of the precision vacuum platten. The vacuum pump is plugged into a 120 VAC receptacle to start suction. The three-way vacuum stopcock will either open the system to air for film release, maintain a vacuum from the stopcock to the vacuum pump, or apply vacuum to the platten to hold the film. With the vacuum applied to the platten, air will be drawn through the platten until the film to be mounted has sealed all of the grooved opening of the platten. This is sometimes facilitated by positioning a second piece of film or paper (to prevent fingerprints) over the first and evenly pressing the film to be mounted until it is held by the vacuum. The auxilliary film is then removed.

Calibration

Due to the critical focusing requirements for 1:1 rephotography, the apparatus is equipped with a precision translation table. A highly fluorescent 1-228 lp/mm resolution target is provided to focus the photographic system. The 35 mm fluorescent target is positioned on the vacuum platten. The apparatus is shown in position for fluorescence photography in Figure 8 (Section IV). The lamp housing is positioned at a 45 degree angle from the fluorescent film plane and about three inches distant from the fluorescent film (or as close as possible). The power supply is turned on and the lamp ignition push button depressed for one half second to ignite the mercury lamp.

The fluorescing resolution target will be visible through the camera's 6X magnification view finder. The camera mount translation table is moved using the micrometer to focus the image. It is possible to focus target group 5 element 6 (57 lp/mm) by eye.

For higher resolution applications, it is possible to focus to group 6 element 3 (81 lp/mm) by conducting a through-focus calibration. The translation unit has 25 mm travel and a tracking accuracy of $\pm$ 1 micrometer (10^{-3} mm). Positioning is controlled by a micrometer that reads directly to 0.01 mm. A typical through-focus calibration determination is shown in Table 9. Once the optimum calibration focus is determined for Eastman Kodak Type 2415 film, the optimum focus setting can be obtained for other films using Table 10. This correction is extremely small except for ultra thin base (UTB-1.5 mils) and ultra ultra thin base film (UUTB-1.2 mils).

Table 9

THROUGH-FOCUS CALIBRATION*

Micrometer Setting (mm)	Resolution Readout Group/Element	Resolution lp/mm
20.00	5/1	32.0
20.10	5/2	40.3
20.20	5/6	57.0
20.30	6/2	71.8
**20.40	6/3	80.6
20.50	6/2	71.8
20.60	5/6	57.0
20.70	5/3	40.3
20.80	4/6	28.5
20.90	4/3	20.2
30.00	3/6	14.3

*This study was conducted using 8 second exposures on Eastman Kodak Type 2415 film using f/4. Identical resolution maxima were obtained using f/3.5 and f/5.6.

**Optimum calibration focus

Intensification by Fluorescence Photography

Once the focus has been adjusted for the original negative film type using Table 10, the calibration resolution target is released by turning the 3-way valve so that the vacuum is redirected through the unconnected valve opening. The fluorescence toned original image is then inserted and the vacuum reestablished on the platten to hold the fluorescent dye toned (rhodamine B) film.

Eastman Kodak Type 2415 film (formerly SO-115) has been found to be suitable for fluorescence rephotography of rhodamine B due to its exceptional red sensitivity and low reciprocity failure. The effective speed change for exposures of 1000, 100, 10, 1 and 1/10 second are -70%, -50%, -20%, None and + 20%.

Intensification by fluorescence rephotography is conducted in the same manner as calibration, except that the length of exposure is varied to control the degree of intensification. Severely underexposed original images require longer fluorescence photography exposures than moderately underexposed original images. In practice, it is easiest to fully bracket the exposure range by beginning an exposure sequence consisting of 1/4, 1/2, and 1 second exposures and then completing the sequence with externally timed exposures using the B setting for exposures of 2, 4, 8, 16, 32, 64 (1m 4s), 128 (2m 8s), 256 (4m 16s), and 512 seconds (8m 32s). These 12 exposures will bracket the optimum exposure and permit enhancement of 3 frames of imagery per 36 exposure roll of 2415. Development of the enhanced images should be conducted with a high contrast developer such as D-19 for 4.0 min at 68°F). After development of the fluorescence photography roll, it may be desirable to obtain additional exposures at intermediate exposure times to provide a narrower range of enhancement exposures or to obtain additional copies of optimally exposed images.

Table 10

FOCUSING CORRECTION INCREMENT

Eastman Kodak Film Type	Film Thickness (mils)	Film Thickness (mm)	Focus Change* (mm)
1414	2.0	0.005	-0.008
2403	5.4	0.013	0.000
2415	5.4	0.013	0.000
2460	5.4	0.013	0.000
2475	5.4	0.013	0.000
2476	5.4	0.013	0.000
3400	4.6	0.011	-0.002
3401	4.6	0.011	-0.002
3412	4.6	0.011	-0.002
3414	3.0	0.007	-0.006
3460	5.4	0.013	0.000
5069	5.4	0.013	0.000
5369	5.4	0.013	0.000
5460	5.4	0.013	0.000
SO-315	1.8	0.004	-0.009
SO-415	4.6	0.011	-0.002

*Relative to initial calibration with Eastman Kodak Film Type 2415.

VII CONVERSION APPARATUS FOR PHOTOINTERPRETATION MICROSCOPE

Conventional photointerpretation binocular microscopes can be easily converted to fluorescence microscopes for photographic image enhancement purposes by the use of apparatus contained in the optical kit. Two sharp cut-off filters, modified to 24 $\pm$ 1 mm diameter, are supplied for insertion into the microscope eyepieces. These filters prevent all light having wavelengths less than 610 nm from entering the eye. The round filters can be inserted into objectives that either screw apart or objectives that have plastic eyecups.

The fluorescent film to be observed is placed under the microscope in the identical manner as for viewing the image by transmitted light. The mercury lamp housing mounted on the adjustable stand is oriented to illuminate the film from above as shown in Figure 13. The emitted red fluorescent light will be visible through the eyepiece at the desired magnification. The intensity of the image can be varied by moving the green light excitation source to different distances from the fluorescent film.

Appendix A

INSTRUCTIONS FOR THE ELECTRONIC TIMER

GRALAB

MODELS 500, 520 (Automatic Reset) DIGITAL DARKROOM TIMERS

ENGLISH

OPERATING INSTRUCTIONS

Your new GraLab Darkroom Timer has been designed to meet all general darkroom timing requirements, including automatic reset for fast production work. It provides precision timing control not only of contact printers or enlargers, but also of tray, tank, or drum processing of film or prints. A quartz crystal time base means less sensitivity to power line interference and greater accuracy regardless of line frequency variations.

CONTROLS IN BRIEF

On-Off Switch (1) — When in "Off" position, there is no power to operate the timer and no power to outlet receptacles In "On" position, timer will operate and power is available at outlets.

Expose/Focus Selector (2) — In "Focus" position (FOC), there is power to Enlarger Outlet (15) but no power to Safelight Outlet (14) unless Safelight Control (3) is on. In "Expose" position (EXP), when timer is not cycling, there is power to Safelight Outlet but no power to Enlarger Outlet. When timer is cycling, there is power to Enlarger Outlet but no power to Safelight Outlet.

Safelight Control (3) — In "Safelight" position (S'LITE), there is power to Safelight Outlet (14) only when Expose/Focus Selector (2) is in "Expose" position (EXP) and timer is not cycling. In "On" position, there is constant power to Safelight Outlet.

Tone Switch (4) — In "Off" position, there is no tone at end of cycle. In "Tone" position, a two-second tone indicates the end of preset time.

Hi/Low Brightness Control (5) — "Hi" position provides bright display. "Low" position provides good readability in total darkness.

Metronome Switch (6) — In "Metronome" position (METRO), a ¼ second tone sounds each second during timing cycle This signal can be activated at any time during the timing cycle.

Time Setting Buttons (8) — Press down to cycle each display digit to desired setting, or tap the value in one digit at a time.

Clear Button (9) — Clears readout display and memory when timer is not cycling. When timer is cycling, resets display and timing cycle.

Cycle 1-2 Selector Button (10) Model 520 — Two time settings may be programmed. When timer is first turned on, cycle 1 is ready for time setting. Enter cycle 1 time. To set cycle 2 time, tap button (10) once. (Note: All nines will be displayed—tap button (9) to clear display). Enter cycle 2 time. Cycle lights 1 & 2 indicate which programmed time is being displayed. The two time settings will remain programmed and can be recalled until Clear Button (9) is pressed for each setting.

Expose Button (11) — Starts timing cycle or restarts from "Hold." Will not operate when Expose/Focus Selector (2) is in "Focus" (FOC) position. Indicator light above control is on in a steady state when timer is not cycling. When timer is cycling, indicator light flashes once per second.

Hold Button (12) — Freezes time during timing cycle. Indicator light is on in this mode. Press "Expose" (11) to proceed with timing cycle.

Foot Switch Jack (13) — (Optional accessory) Extends "Expose" for "hands off" control.

PRINTING OPERATION

(1) Plug Safelight and Enlarger into outlets 14 and 15 respectively.

(2) Set Expose/Focus Selector (2) to "Focus" (FOC) to turn on Enlarger for focusing and framing.

(3) Set Expose/Focus Selector (2) to "Expose" (EXP) and enter exposure time with Time Setting Buttons (8).

(4) Press "Expose" (11) to start cycle: Safelight is off and Enlarger is on. During timing cycle "Hold" (12) freezes time. "Clear" (9) resets timing cycle — Enlarger is off and Safelight is on. At end of cycle, Enlarger is turned off and Safelight is turned on.

PROCESSING OPERATION

Set time for first step of processing with Time Setting Buttons (8).

Turn Signal Switch (4) to "Tone." Pour chemical into tank or drum or put material in tray, promptly pressing "Expose" (11).

At end of preset time, signal will sound. Empty chemical or remove material from tray.

Set next process time value into timer and proceed.

OTHER FEATURES

Inclining Stand — Pull stand out of slot and insert short side into grooves on back of timer.

Wall Mounting — Keyhole slots on back of timer.

PRECAUTIONS

Use timer only at AC voltage and power frequency printed on rear nameplate.

Be sure appliance load does not exceed maximum specified for each outlet receptacle.

For use with voltage regulator, connect as follows: timer to voltage regulator (stabilizer) to enlarger.

Protect timer from jars and knocks

Avoid spilling liquids on timer.

A certain GraLab timer may suit your requirements better than other models. Please request bulletins describing range of GraLab timer models and specifications.

SPECIFICATIONS

Timing range is .1 sec to 99 min., 59.9 sec.

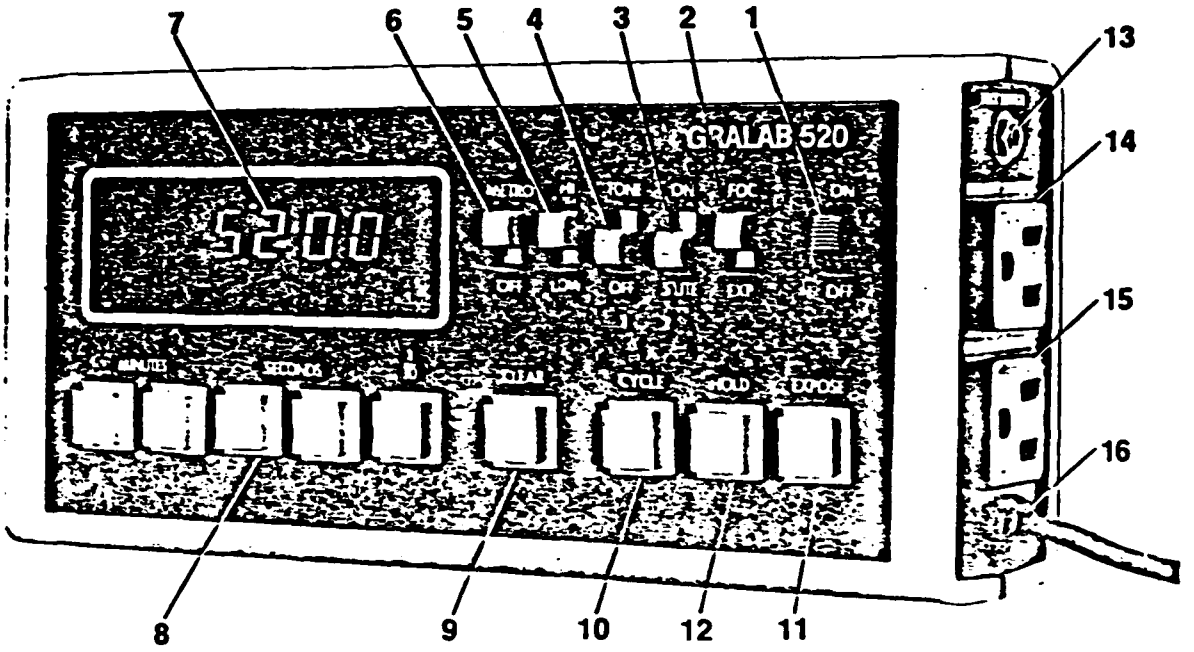
UL and CSA listed. Three-wire grounded cord and outlet receptacles. 1000 watts total load capacity for the combined outlet receptacles (700 watts for enlarger or printer, 300 watts for safelight).

Input voltage 125 VAC, 50/60 Hz (U.S. and Canada). 250 VAC, 50/60 Hz available for use in other countries.

*Accuracy @ 20° C	*Repeatability @ 20° C
± .015% @ 1 Hr.	± .002% @ 1 Hr.
± .15 % @ 1 Min.	± .02 % @ 1 Min.
± 1.5 % @ 1 Sec.	± .5 % @ 1 Sec.

Temperature Range	Humidity
0° C – 55° C	0 – 95% Non-condensing

*From start of timing cycle to actuation of power outlets.



ENGLISH

1. On-Off Switch
2. Expose/Focus Selector
3. Safelight Switch
4. Tone Switch
5. Hi/Low Brightness Control
6. Metronome Switch
7. Digital Time Display
8. Time Setting Buttons
9. Clear Button
10. Cycle 1-2 Selector Button (Model 520)
11. Expose Button
12. Hold Button
13. Foot Switch Jack
14. Safelight Outlet
15. Enlarger or Printer Outlet
16. Three-Wire Grounded Cord

ESPAÑOL

1. Interruptor cierre-apertura
2. Selector exposición/enfoque
3. Interruptor de luz de seguridad
4. Interruptor de tono
5. Control de luminosidad alta/baja
6. Interruptor de metrónomo
7. Hora digital visible
8. Botones para fijar el tiempo
9. Botón de despejar
10. Botón selector de ciclo 1-2 (Modelo 520)
11. Botón de exposición
12. Botón de mantención de exposición
13. Enchufe para interruptor pedal
14. Salida para luz de seguridad
15. Salida para ampliador o impresora
16. Cable trifilar con conexión a tierra

DIMCO-GRAY COMPANY
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Printed in U.S.A.

Appendix B

UNIVERSAL ARC LAMP SUPPLY

GENERAL DESCRIPTION

The 27-1015 Universal Arc Lamp Supply is a current-regulated, line voltage regulated, continuous-duty, isolated D.C. Power Supply designed to operate Xenon, Mercury, and Mercury/Xenon Short Arc Lamps in the range 75 - 250 watts within the limits of current and voltage of the supply.

The Power Supply is a series transistor type employing a closed loop feedback system and integrated circuit regulator to provide regulation and active ripple filtering. The supply is current limited and short circuit protected and includes a thermal device on the main transistor heat sink to protect against overtemperature.

The supply has three ranges of operation manually controlled by a switch on the front panel which provide for the three main current and voltage categories of lamps which the supply will operate. Current control within the established ranges is by the "Current Adjust" potentiometer also on the front panel.

In the first position labelled "75 Xe./100Hg.," the supply will operate between 5 and 6.9 amperes and between 14 and 24 volts; in the second position labelled 150Xe./200Hg.-Xe. between 6.5 and 9.5 amperes, and 18 and 27 volts; and in the third position labelled 200 Hg. between 3.1 and 4 amperes, and 50 and 65 volts.

INSTALLATION

The power supply is fully equipped as supplied to operate the short arc lamps listed above and other falling within the listed voltage and current tolerances. It is supplied with a line cord for connection to a 115 volt A.C. 50/60 Hz. line.

A screwdriver slide switch on the rear panel may be used to set the power supply for 230 volt AC 50/60 Hz line.

Output is by means of an Amphenol multipin high voltage connector. An appropriately terminated high voltage cable is supplied for connection to the lamphouse. If alternative cables are used they must have insulation capable of 20 KV.

The igniter in the power supply is a low noise, single shot type which produces a minimum of electro magnetic radiation. It is desirable, however, to keep the leads to the lamphouse as short as possible to minimize interference of the start pulse with sensitive semi-conductor instrumentation and to facilitate lamp starting. The recommendation for lamphouse leads is under one meter. If the leads must be longer, provide good separation between the conductors. Select lamp leads with adequate high voltage insulation and route them away from grounded metal between the supply and lamp house.

Connect the three prong power plug to a grounded A.C. outlet.
- verify that the outlet can provide 5 amps at 115 volts A.C. or 3 amps at 230 volts A.C.
- that the outlet is properly grounded

Connect the lamp or lamphouse with appropriate cables to the power supply.
- verify that the lamp is connected in the proper polarity Xenon and Mercury lamps mounted vertically will be connected in the inverse of one another (see Manufacturer's Instructions).

When using the Ealing 27-1031 Stabliarc 250 lamphouse it is not possible to connect the lamp with the wrong polarity. A microswitch within the lamphouse is activated by the adapters supplied when voltage inversion is necessary. The high voltage output is normally positive but when the microswitch is closed the output switches to negative.

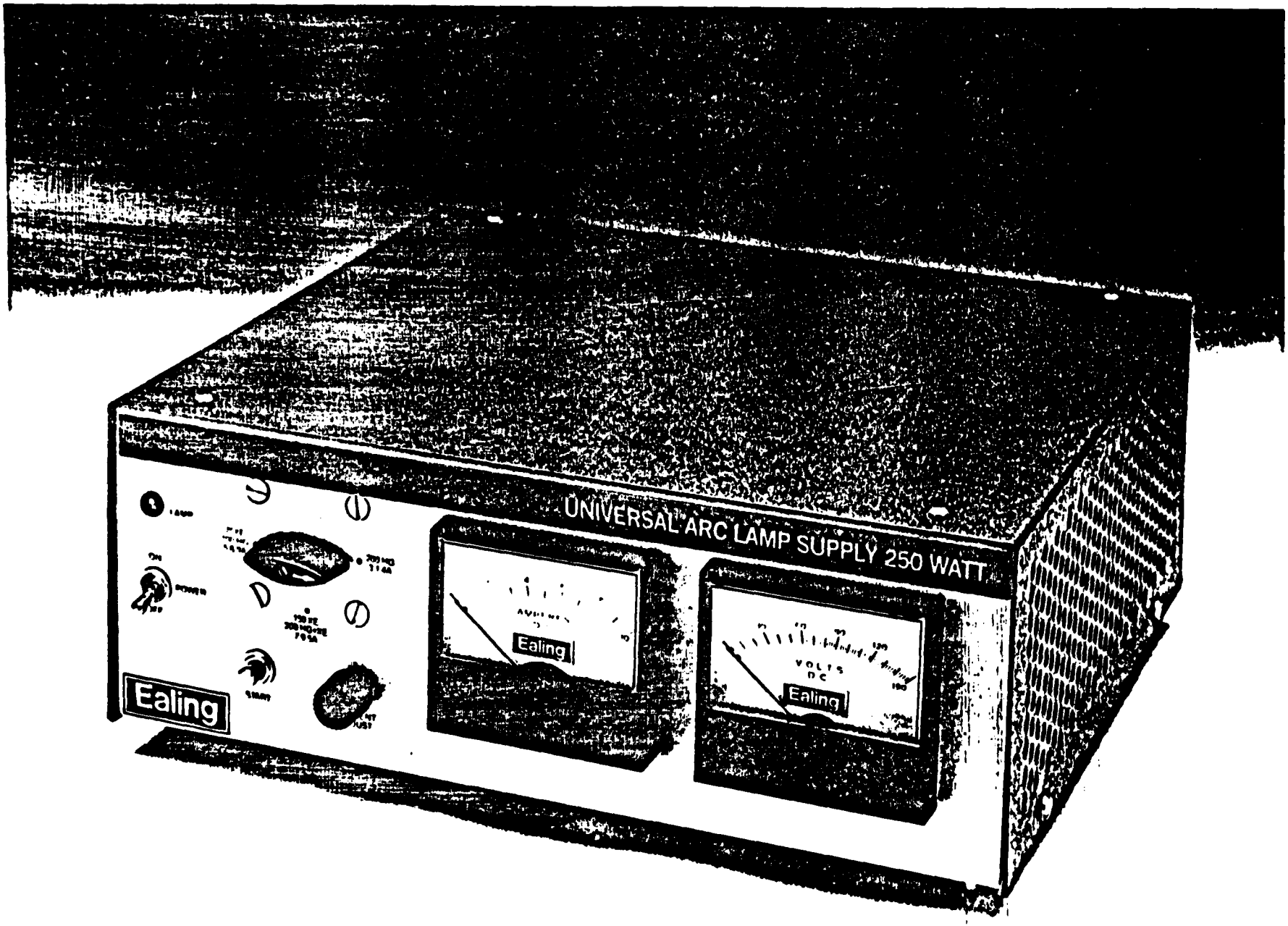
When using the Ealing 24-1411 Stabilarc 100 lamphouse care must be taken to connect the lamps in the correctly marked orientation.

For alternative lamphouses take care to make correct connections.

> CAUTION
>
> A polarity inversion invariably results in lamp failure. Make a ground connection between the lamphouse and power supply cases. This is an earth ground. The power supply case will be grounded already via the green lead and "U" ground of the A.C. receptacle. Do not ground positive or negative in the lamphouse.

OTHER VOLTAGES AND FREQUENCIES

The power supply is shipped connected for 115 volts A.C. It will operate from either a 50 or 60 Hz. line without changes. It is provided with a rear panel slide switch for connection to 230 volts A.C. 50 or 60 Hz.


UNIVERSAL ARC LAMP SUPPLY 250 WATT
Ealing
Ealing
Ealing

FUSING AND THERMAL PROTECTION

The power supply is protected from overload by two fuses accessible from outside the supply and one thermal switch. The main power fuse is a 5 amp slo-blo type Buss MDX 5. It protects the main power circuitry and is in series with the power line. A secondary fuse 15/100 amp slo-blo Buss MDL 15/100 protects an auxiliary rectifier transformer and its associated circuitry. The thermal, mounted on the main transistor heat sink, is of the automatic reset type.

OPERATION

The power supply is preset to operate within the ranges as indicated for the three positions of the selector switch. Select the proper range for your lamp. Turn power switch on and press Start button - hold for 1/2 second for most reliable starting. When the lamp ignites, the ammeter will indicate operating current. Adjust for desired current with the current adjust pot. If the lamp does not light on the first try, release the start button and try again. Do not hold the start button for long periodsof time i.e. 5 seconds or longer. The resistor R1 will overheat.

The power supply operates through three modes sequentially and automatically to start and run short arc lamps. These are Start, at the instant the start switch is depressed, Sustain, in the interval when the switch is held, and Run, after the switch is released. The Start pulse is generated in the ignite circuit and is in the order of 20 KV. It causes the Xenon or Mercury gas in the lamp to ionize. Once ionized, the arc is developed by the energy stored in the filter capacitor and sustained by an auxiliary boost circuit completed by the start switch. This circuit operates at approximately 150 volts D.C. When the button is released, main run current is supplied by the series transistor output circuit and its parallel resistors. This final circuit is highly regulated against changes in line and load and provides active ripple filtering to approximately 1000 Hz.

OPTIONAL FEEDBACK CONTROL

Additional fine control of lamp output may be achieved with the use of a 27-1361 Optical Feedback Amplifier A.C. A beamsplitter attachment on the output port of the lamphouse samples a small portion of the emitted beam which is passed to an accessory

detector-amplifier via a fiber optic cable. The detector-amplifier serves to close the optical-electrical control loop and connects to the power supply at a back panel connector.

For arc lamps this system may be used to minimize the effects of arc wander. Even with the best electrical stabilization arc wander can cause some variation of light output. By A.C. coupling the feedback amplifier these changes of output may be reduced to a very low level. Long term drift effects in arc lamps are unlikely to cause a problem but a D.C. coupled version of the Optical Feedback Amplifier is available to control long term lamp variations if needed.

Complete details on operation of the feedback control system are described in a separate manual.

Without the accessory feedback control device the connector on the power supply back panel may be ignored. There are no adjustments to be made in the power supply itself pertaining to the use, or non-use, of the feedback control device.

SPECIFICATIONS

Input	105-130VAC, 210-260VAC, 50/60Hz. 4A/2A
Output	
Open Circuit	150 Volts D.C.
Operating Voltage	12-65 Volts D.C.
Operating Current	3-10 Amps.
Output Power	250 Watts
Ignition Voltage	20 KV pulsed
Current Ripple	0.5% peak to peak max. (0.17% RMS)
Line Regulation	0.1% through range of line operation
Typical lamps operated	75 Watt Xenon 100 Watt Mercury 150 Watt Xenon 200 Watt Mercury 200 Watt Mercury/Xenon
Operating Temperature	10°C - 50°C

Front Panel Controls
- Power on/off switch and indicator light.
- Output range selector.
- Fine current adjust potentiometer.
- Start Button.
- 0-10 D.C. Ammeter.
- 0-150 D.C. Voltmeter.

Rear Panel Controls

Amphenol Multipin Socket Outlet for lamp connection.
Line voltage input selector 115/230 v A.C.
5 amp slo-blo input line fuse.
0.15 amp slo-blo fuse for rectifier.
Optical feedback amplifier connector socket.
(adjusts approximately ± 10% of front panel current setting).
Socket outlet for fan connection 115 v A.C. 0.25 amp

Size 356W x 145H x 318D mm
(14W x 5½H x 12½D index)

Weight 18.5 kg (41 lb)

Normal Max Power Consumption: 500 watts.

Appendix C

STABILARC 100 LAMPHOUSE

GENERAL DESCRIPTION

The Stabilarc 100 Lamphouse is a simple, versatile and low cost enclosure for the mounting of tungsten halogen and short arc lamps to 100 watts. It is provided with mountings for the typical 75 watt Xenon and 100 watt Mercury short arc lamps, and the 12 volt 100 watt Tungsten Halogen lamp. The housing includes an Aspheric condenser 31.5 mm dia x 25 mm f/1 for efficient collection of the lamp energy. The lamp holder is provided with external means for focus, horizontal and vertical adjustments.

The lamp housing is equipped with a filter holder for use with up to three 50 mm square or circular filters. It will accept a standard 13.7 mm pin for mounting on Ealing optical benches center height of 7 inches.

INSTALLATION

The lamphouse is a free standing unit and may be placed directly on a working surface. It may also be pin mounted on an optical bench. A standard Ealing 22-7892 Short Mounting Pin will screw into the base of the lamphouse. Alternatively the 27-0876 Side Mounting Adapter or 27-0884 Lamp Stand may be used to support the lamphouse.

This single lamphouse may be used to mount any of the following lamps:

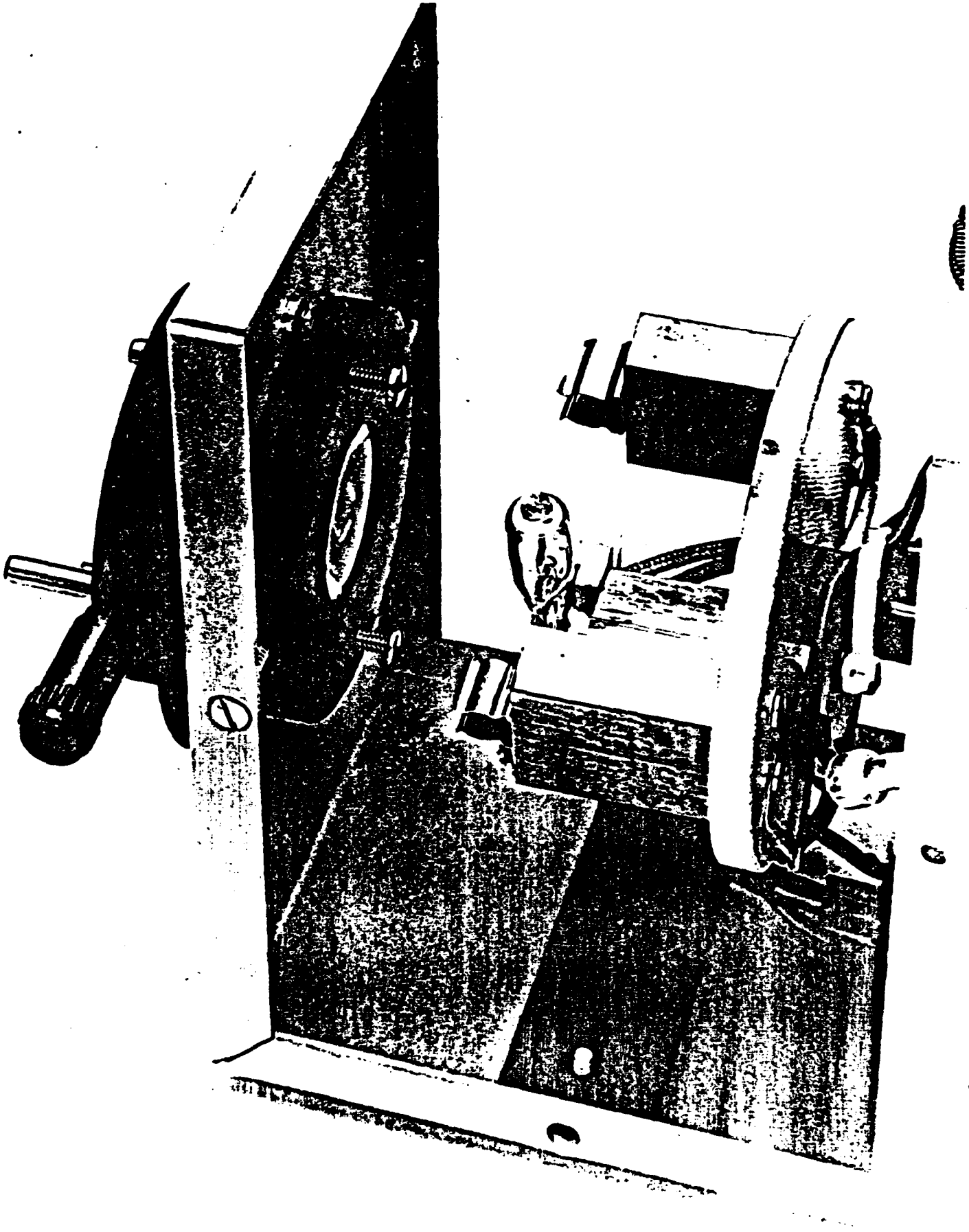
28-8472	100w Tungsten Halogen	
28-8498	75w Xenon arc	
28-8480	100w Mercury arc	or equivalents.

It is provided with a cable suitable for supplying power to a 100w tungsten halogen lamp. If it is intended to use an arc lamp an additional cable must be purchased.

27-1452	Cable for Arc lamps
27-1445	Cable for Tungsten lamps.

LAMP INSTALLATION

- To install the lamp first remove the wrap over cover by taking out the two knurled thumbscrews.



- Unscrew the knob on the rear of the lamphouse and push forward until the mounting disc is clear of the restraining pins.

- Rotate the disc to the appropriate orientation for the lamp to be used. Take note of markings on the terminal blocks:

XE	UP
HG	UP

- Now retighten the knob on the rear panel. When fully tight there will still be a small angular adjustment available. This is intentional.

- Take the lamp to be used and attach it to the appropriate terminals.

> **CAUTION**
>
> Take care when handling high pressure lamps and always wear safety glasses. Observe the instructions packed with the lamps.

- Replace the cover.

OPERATION

- Connect the lamp to an appropriate power supply. For tungsten halogen a 12v AC or DC supply may be used. For arc lamps a special DC supply is required. Appropriate Ealing supplies are:

Halogen	12v	AC	27-0918 (115v input)
			27-0926 (230v input)
	12v	DC	27-1403
Arc			27-1015

- Switch on the supply.

- Verify that light is emerging from output part.

The lamphouse is provided with X Y and Z adjustment to the lamp. This can be used to optimize the illumination conditions. For best results follow the procedure below:

1/ Push or pull the knob on the back plate to focus the filament or arc at about 1 meter from the housing.

2/ Lightly clamp the shaft with the knurled finger screw.

3/ Rotate the knob at the back slightly to adjust lateral position of image. (Image moves in an arc giving both tilt and lateral shift effects.)

4/ Adjust vertical position of image using top adjust knob.

5/ Refocus at required distance and repeat 2, 3, 4.

OPTICAL FEEDBACK CONTROL

In order to stabilize the output and minimize the effects of arc wander, mechanical vibration or long term drift, a feedback loop may be employed.

The Ealing 27-1361 Optical Feedback Amplifier, AC or the Ealing 27-1353 Optical Feedback Amplifier, DC are supplied complete with beamsplitter and fiber optic probe for attachment to the Stabilarc 100 lamphouse.

If it is required to stabilize AC effects such as arc wander the 27-1361 should be used. It may be coupled directly to the Ealing 27-1015 Universal Arc Lamp supply to control the luminous output of the lamp to better than 0.1%

If longer term effects such as drift or filament ageing are important the 27-1353 should be used. This may be coupled to either the Ealing 27-1015 Universal Arc Lamp supply or the Ealing 27-1403 Stabilized Lamp power supply to control the luminous output of the lamp within 0.1% over 5 minutes or 0.5% over 1 week.

Details of operation are given in the Optical Feedback Amplifier Manual.

SPECIFICATIONS

Optical System:	Aspheric Condenser 25 mm f/0.7 focusing from zero to 4 m
Cooling:	Inner radiation shield Outer ventilated case for connection Temperature <64°C

LUMINOUS OUTPUT AT 1 METER

	Flux (mW/mm^2)	Dimensions of Luminous area (mm)
100w WI	12	108 x 59
75w Xe	42	6.5 x 13
100w Hg	56	6.5 x 6.5

Dimensions	115W x 172H x 140D mm (45W x 67H x 5-5D index)	
Weight	1.7Kg	(3.75lbs)

SPARES

For a spare cable for tungsten halogen	order	27-1445	
For a spare cable for arc lamps	order	27-1452	
For spare lamps	order	28-8472	100wWI
		28-8498	75wXe
		28-8480	100wHg

POWER SUPPLIES

For Arc lamps	order	27-1015	
For Tungsten lamps (AC supply)	order	27-0918	(for 115v input)
		27-0926	(for 230v input)
For Tungsten lamps (DC supply)	order	27-1403	

ACCESSORIES

Stand	order	27-0884
Side Mounting Adapter	order	27-0876
Mounting Pin	order	22-7892

FEEDBACK CONTROL

For an AC coupled feedback amplifier	order	27-1361
For a DC coupled feedback amplifier	order	27-1353

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